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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

RESULTS OF CODLING MOTH INVESTIGATIONS, 1944

Part I

Work Conducted by State Agencies,
Entomological Branch, Canadian
Department of Agriculture
and
Commercial Entomologists

Not for Publication

This pool of information on the results of codling moth research for the season of 1944 is the twelfth of a series of similar summaries prepared annually by the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture, at the request of the Committee on the Codling Moth of the American Association of Economic Entomologists. These data are assembled for the confidential information of workers who are interested in the codling moth problem. The material is not for publication and is therefore not available for quotation or other use without specific permission from the agency which has furnished it.

CALIFORNIA

A. D. Borden, California Agricultural Experiment Station, Berkeley

I. Seasonal condition and status of infestation.

The bait trap records of the first brood showed a decrease in the catch of adult moth as compared with other years and the low temperatures prevailing in May and June apparently lessened first brood attacks. Rising temperatures in July and August were more favorable to a second brood attack and where the first brood sprays were not properly timed or applied, the percentage of wormy fruit was fairly high at harvest. In well timed programs the loss of fruit from worms was very low.

III. Results of control experiments.

A. Control by insecticides.

(1) Lead arsenate - Much time and effort was spent this season in trying to get satisfactory deposits from commercial spreaders used with lead arsenate. Due to war conditions, some of the necessary ingredients in these spreaders were not available and substitute materials were used which generally resulted in poor deposits. This condition was not improved as the season advanced. Some improvement for the coming season is promised.

(4) Organic materials.

(c) Xanthone - Over 4,000 pounds used commercially by growers in all the major fruit districts with very satisfactory results in both codling moth and mite control. Some low deposits were obtained for the lack of a suitable depositing agent.

(d) Other organic materials. Dow DN-111 used extensively by growers for mite control gave good results where applications were timed with occurence of early mites. Many poorly timed applications.

IV. Experience of growers in obtaining insecticides and spray equipment during 1944.

(1) Rotenone--practically none available for thrip control on pears.

(2) Pyrethrum--no concentrate available. Pyrethrum "marc" used successfully on cankerworms and tussock moth larvae.

(3) Nicotine sulphate supply very limited.

(4) Equipment allocations not meeting demand for replacements. The introduction of a limited number of SPEED SPRAYERS very promising in relieving man-power shortage. This equipment gave excellent coverage in arsenical cover sprays.

V. Use of DDT in codling moth control on Bartlett Pears.

(1) Geigy 20% concentrate in oil and as a wettable material used as delivered at a dosage equivalent to one pound actual DDT per 100 gallons in cover sprays following two arsenical sprays showed no worm attack in a sampling of over 4,000 fruit from eight large trees. Some leaf injury occurred from the material in oil. The wettable form (A-20) gave excellent wetting and no injury. No beneficial insect eggs noted on fruit until very late in season. Mites appeared earlier and more severe on DDT sprayed trees.

(2) Geigy 20% concentrate in oil controlled pear thrips larvae and leaf roller and tussock moth larvae on apples and pears in a single application of 2.5 quarts per 100 gallons. Some leaf injury noted.

CALIFORNIA (Continued)

G. E. Carman and C. A. Fleschner, California Agricultural Experiment Station, Riverside.

III. CONTROL EXPERIMENTS

Limited field tests were undertaken on Rome Beauty Apples, Bartlett Pears, and Kelsey Plums, to determine the efficiency of various lead arsenate programs and the value of other insecticide materials, particularly DDT, in codling moth control. Recommended grower schedules were followed and the timing of spray applications was determined by the trend of bait pail catches in each area and by periodic field observations.

The DDT materials used in the tests were supplied by the Geigy Company, Incorporated. On apples and pears these preparations were used without spray supplements except for a small amount of blood albumin spreader in conjunction with the DDT-oil solution (Gesarol SHN20). The DDT-pyrophyllite mixture (Gesarol AK20) was slurried with water before being added to the partly filled spray tank. Fungicides were not required in any of the spray schedules.

A. Rome Beauty Apples, Rivers Ranch, Oak Glen

1. Experimental set-up. The spray schedules employed with the test materials and the dates of application are indicated in Table 1. Single tree replicates were used. No trees were retained as untreated checks. The results of the test were established by an examination of all drop fruits and of a sample of 1000 harvested fruits from each tree.

2. Summary of results. The results of the summarized codling moth data and of the analyses for surface residues of DDT at harvest are given in Table 1. All analyses for DDT residues reported in this paper were made by Mr. F. A. Gunther of this Station using the dehydrohalogenation method developed by him.

The DDT-pyrophyllite mixture gave outstanding codling moth control, and the practical dosage appeared to be slightly less than 5 pounds per hundred gallons of water. The heavy residues from these sprays resulted in splotchy fruit coloring. Greatly increasing the time between applications of DDT or discontinuing all applications after early cover sprays gave inadequate protection. However, in commercial practice, sufficient control of first brood worms with DDT might make possible certain modifications in the spray schedule against later broods. No injury to foliage or fruit was observed from any of the treatments, and 2 or 3 quarts of DDT-oil solution could probably be applied safely with an increase in efficiency over the schedules used in this test.

While Tetranychid mites did not become a problem in the test orchard, large numbers of Bryobia mites were observed on all trees except for only limited numbers on the xanthone sprayed trees. Woolly apple aphid colonies developed in significantly larger numbers on lead arsenate sprayed trees than on DDT sprayed trees.

DDT surface residue analyses substantiated the codling moth data in indicating a loss and/or decomposition of the compound following spray applications on fruit.

TABLE 1. CODLING MOTH TEST ON ROME BEAUTY APPLES, OAK GLEN

Note: A calyx spray of lead arsenate (3-100) was applied by grower to entire test block, May 18-19.

Materials (unit of measure)	First May 28-29	Second June 5	Third June 14-15	Fourth July 1	Fifth August 8	Sixth August 25	Number of trees	Per cent Wormy	Per cent Stung	Per cent Clean	Worms per 100 fruits	Stings per 100 fruits	DDT residues in p.p.m. wet weight October 26 7/
1. Gesarol AK20 1/ (lbs.)	2½	2½	2½	2½	2½	2½	5	2.8	7.5	89.7	3.0	11.1	1.7
2. Gesarol AK20 (lbs.)	5	5	5	5	5	5	5	0.8	2.8	96.4	0.9	3.6	5.2
3. Gesarol AK20 (lbs.)	7½	7½	7½	7½	7½	7½	5	0.7	3.4	95.9	0.8	4.4	7.0
4. Gesarol AK20 (lbs.)	5	-	5	-	5	-	5	10.0	14.3	75.7	11.4	26.0	1.0
5. Gesarol AK20 (lbs.)	5	5	-	-	-	-	2	32.5	12.4	55.1	43.8	34.9	0.0
6. Gesarol AK20 (lbs.)	5	5	5	-	-	-	2	20.6	11.8	67.6	27.2	25.5	0.4
7. Gesarol AK20 (lbs.)	5	5	5	5	-	-	1	7.5	10.8	81.7	10.2	17.6	0.5
8. Gesarol AK20 (lbs.)	5	5	5	5	5	-	2	1.1	4.2	94.7	1.2	4.8	1.3
9. Gesarol SHN20 2/ (qts.) Blood albumin spreader(ozs)	1 2	1 2	1 2	1 2	1 2	1 2	5	11.4	11.8	76.8	13.7	22.0	1.0
10. Gesarol SHN20 (qts.) Blood albumin spreader(ozs)	2 2	- -	2 2	- -	2 2	- -	5	8.3	8.5	83.2	9.7	14.5	1.7
11. Gesarol SHN20 (qts.) Blood albumin spreader(ozs)	1 2	1 2	- -	- -	- -	- -	2	60.2	8.5	31.3	80.8	32.4	0.0
12. Gesarol SHN20 (qts.) Blood albumin spreader(ozs)	1 2	1 2	1 2	- -	- -	- -	2	34.8	9.2	56.0	42.5	22.4	0.2
13. Gesarol SHN20 (qts.) Blood albumin spreader(ozs)	1 2	1 2	1 2	1 2	- -	- -	2	32.1	12.0	55.9	46.8	35.1	0.3
14. Gesarol SHN20 (qts.) Blood albumin spreader(ozs)	1 2	1 2	1 2	1 2	1 2	- -	2	14.8	10.2	75.0	17.6	20.7	0.0
15. Acid lead arsenate (lbs.)	3	3	3	3	3	3	5	33.7	18.8	47.5	45.3	61.7	--
16. Acid lead arsenate (lbs.) Xanthone 3/ (lbs.) Genifilm A 4/ (ozs.) Kerosene (qts.)	3 - - -	3 - - -	- 2 8 1	- 2 8 1	- 2 8 1	- 2 8 1	5	16.3	7.5	76.2	19.2	16.0	--
17. He 761 5/ (lbs.) Pyrophyllite 6/)(lbs.)	1 4	1 4	1 4	1 4	1 4	1 4	5	31.8	25.3	42.9	38.4	65.8	--

1/ A milled mixture of 20 per cent DDT and 80 per cent pyrophyllite supplied by the Geigy Co., Inc.

2/ A solution of 20 per cent DDT in a summer type oil and mutual solvent supplied by the Geigy Co., Inc.

3/ A proprietary mixture of dibenzo gamma pyrone and dibenzo gamma pyrone derivatives supplied by the General Chemical Company, and marketed as Genicide.

4/ A spray supplement supplied by the General Chemical Company for use with Genicide in spray suspensions.

5/ Experimental compound furnished by the Rohm and Haas Company.

6/ Pyrax ABB supplied by the R. T. Vanderbilt Company.

7/ DDT residue analyses were made by Mr. F. A. Gunther, Citrus Experiment Station, Riverside, California.

3. Removal of DDT surface residues. The apples used in the wash tests were sampled from trees which received 7 1/2 pounds of DDT-pyrophyllite mixture in six cover sprays. The tests were run in a flood-type washer of recent design. Duplicate samples of 40 apples each were taken from each wash for the residue analyses. An additional sample was taken and the apples placed in cold storage. The wash procedures and the results of DDT residue analyses on washed fruits are given in Table 2.

All washes reduced the DDT residues appreciably and combinations of IN-181-P washes and sodium silicate washes appeared to be most efficient. Greater difficulty would be expected if DDT was applied in the calyx spray. In some instances, slight visible deposits remained in the blossom and stem ends following the wash.

Under natural conditions the DDT surface residues on fruits left on the trees for the wash tests dropped from 9.5 p.p.m. wet weight on October 4th to 3.3 p.p.m. wet weight on November 11th.

4. Penetration of DDT into apple fruits. Preliminary studies were made to determine if any DDT penetrated the apples. Samples of 40 apples each were taken from trees which were sprayed in six covers with the DDT-pyrophyllite mixture or with the DDT-oil solution. To remove most of the surface deposit the apples were thoroughly scrubbed with a brush in a warm solution of tri-sodium phosphate. The apples were then stripped with benzene and the amount of DDT remaining on the surface after the scrubbing was determined. The benzene strip also insured complete removal of DDT on the surface which was necessary since the entire fruit minus the core was utilized in the determinations. The data obtained from these studies are presented below:

Treatment	DDT residue in p.p.m. wet weight: Original surface deposit	Surface deposit after scrubbing with trisodium phosphate	Within fruits
Gesarol AK20 at 7-1/2 lb.	7.0	0.5	0.0
per 100 gallons water	7.0	0.5	0.0
	7.0 1/	---	0.4
Gesarol SHN20 at 1 qt.	1.0	0.4	lost
per 100 gallons water	1.0	0.4	0.4

1/ This sample was not stripped with benzene after the scrubbing with trisodium phosphate in order to determine whether or not benzene stripping carries any surface DDT inside the fruit. Since the total p.p.m. for all three of these samples are the same (well within experimental error), it may be concluded that benzene stripping procedure did not carry any DDT into the apples.

TABLE 2. WASH TESTS FOR REMOVAL OF DDT SURFACE RESIDUES. FLOOD-TYPE TANDEM WASHER

Note: DDT residue analyses were made by Mr. F. A. Gunther, Citrus Experiment Station, Riverside, California.

Date	Materials: First tank	Materials: Second tank	Sequence of Wash [1]	DDT residue in p.p.m. wet weight	Per cent removal
1.10-4-44	Sodium silicate[2] (70 lbs-100) heated to 110° F.	Hydrochloric acid (1.25 per cent)	A-B-C-D-E	1.6	83
2.11-1-44		Hydrochloric acid (1.25 per cent) plus ferric chloride (1 ounce-100)	C-D-E-C-D-E	0.8 1.0	82
3.11-1-44	Sodium silicate (82 lbs-100) heated to 102° F.	Hydrochloric acid (1.25 per cent) plus ferric chloride (1 ounce-100)	A-B-C-D-E	0.6 0.6	88
4.10-29-44		4 per cent solution of sodium hypochlorite (3 pts.-100)	C-D-E-C-D-E	0.5 0.7	90
5.11-1-44		6 per cent solution of sodium hypochlorite (2 qts.-100)	C-D-E C-D-E-C-D-E	0.4 0.4	92
6.11-1-44		Mermaid Soap[3] (4 lbs.-100)	C-D-E-C-D-E	0.5 0.2	93
7.11-11-44	Trisodium phosphate (4 lbs-100) heated to 108° F.	Water only	A-B-A-B-C-D-E	0.3 0.3	91
8.10-29-44	Sodium silicate (72 lbs.-100) heated to 107° F.	Water only	A-B-C-D-E A-B-C-D-E	0.5 0.6	91

TABLE 2. (CONTINUED)

Date	Materials: First tank	Materials: Second tank	Sequence of wash 1/	DDT residue in p.p.m. wet weight	Per cent removal
9. 11-11-44	Sodium silicate (70 lbs.-100) heated to 108° F.	IN-181-P 4/ (1 ounce-100)	A-B-C-D-E	0.5 0.6	84
10. 11-11-44	Sodium silicate (70 lbs. -100) heated to 72° F.	IN-181-P (1 ounce-100)	C-D-E-A-B	0.3 0.3	91
11. 10-29-44	Sodium silicate (72 lbs.-100) heated to 107° F.	IN-181-P (1 ounce-100)	C-D-E-A-B	0.1 0.1	98
12. 11-11-44	Sodium silicate (70 lbs.-100) heated to 108° F.	IN-181-P (1 ounce-100)	C-D-E-A-B	0.3 0.4	90
13. 11-5-44		IN-181-P (2/3 ounce-100)	C-C-D-E	0.3 0.3	93
14. 11-5-44	IN-181-P (2/3 ounce-100) heated to 100° F.		A-A-D-E	0.3 0.4	92
15. 11-5-44	IN-181-P (2/3 ounce-100) plus sodium silicate (70 lbs.-100) heated to 108° F.		A-A-D-E	0.4 0.4	91

1/ A-First tank of washer (approximately 300 gallons); B-Water spray between tanks; C-Second tank of washer (approximately 400 gallons); D-Water rinse bath and water spray after second tank; E-Velour drier.
2/ Philadelphia Quartz Company.
3/ Proprietary sodium salt of a fatty acid supplied by the Los Angeles Soap Co
4/ A powder containing 51 per cent sodium lauryl sulfate supplied by the E. I. DuPont de Nemours and Company, Inc.

B. Bartlett Pears, Bones Ranch, Little Rock

The field test was undertaken to determine the value of proposed changes in the lead arsenate spray program and to test spray schedules of the two base materials of DDT. Supplements were used with lead arsenate in the calyx sprays in an effort to increase the amount of poison deposited in the calyces and a gallon of petroleum oil was applied in the first cover spray to provide for mite control without creating a residue removal problem as it was anticipated a later oil spray might.

The spray schedules and codling moth data are given in Table 3. The DDT-oil solution applied at the rate of 2 quarts in the first calyx spray gave some foliage injury and applications were discontinued until the safety of the lower dosage was established. The supplemented lead arsenate sprays in the calyx applications gave improved control but none of the tested materials was significantly better than the others. Poor control of two-spotted mites resulted on all of the lead arsenate sprayed trees, and observations in other orchards in the district indicate that the oil spray can be made in the second cover with better mite control and without complications in residue removal. DDT sprayed trees did not bronze appreciably from two-spotted mite injury. However, tremendous numbers of Bryobia mites were present on all trees in the test block, and particularly on the DDT trees which remained green and were not defoliated early.

DDT residue and penetration studies were made on pears and the results are summarized below.

	DDT residue in p.p.m. wet weight					
	Before washing		After washing 1/		Within fruit	
Treatment	Surface deposit	Calyx 2/ only	Surface deposit	Calyx 2/ only	With calyx	Without calyx
Gesarol AK20 (see Table 3)	1.0	15.0	0.6	16.0	--	--
Gesarol SHN20 (see Table 3)	0.1	0.0	0.1	0.0	1.7	1.4

1/ Washing procedure consisted of subjecting the fruits to the conventional 1.5 percent. hydrochloric acid bath in regular fruit washing equipment as used for the removal of lead arsenate residues.

2/ Based on weight of excised calyces only.

TABLE 3. CODLING MOTH TEST ON BARTLETT PEARS, LITTLE ROCK

Materials (unit of measure)	Calyx sprays: 1st April 15,17	Calyx sprays: 2nd April 22,23	Cover sprays: 1st May 19	Cover sprays: 2nd June 13	Cover sprays: 3rd July 6	Cover sprays: 4th August 1	Per cent: Wormy calyx	Per cent: Wormy side	Per cent: Stung
1. Gesarol AK20 (lbs.)	7½	10	10	10	10	2½	0.2	2.1	1.3
2. Gesarol SHN20 (qts.)	2	--	1	1	1	1	4.8	11.1	5.1
Blood albumin spreader (ozs.)	2	--	2	2	2	2			
3. Acid lead arsenate (lbs.)	4	4	3	--	--	--	28.3	19.2	1.8
Blanket spray (lead arsenate 3 lbs.+ spreader)	--	--	--	X	X	X			
4. Acid lead arsenate (lbs.)	4	4	3	--	--	--	16.6	18.0	1.7
Ortho K NW Flowable 1/ (pts.)	1	1	8	--	--	--			
Blanket spray	--	--	--	X	X	X			
5. Acid lead arsenate (lbs.)	4	4	3	--	--	--	14.7	17.4	1.9
Mixol powder 2/ (ozs.)	5	5	5	--	--	--			
Ortho K NW Flowable (gal.)	--	--	1	--	--	--			
Blanket spray	--	--	--	X	X	X			
6. Acid lead arsenate (lbs.)	4	4	3	--	--	--	13.8	17.0	3.8
XXX Flowable 60 3/ (pts.)	1	1	8	--	--	--			
A-C Spreader 4/ (ozs.)	2	2	2	--	--	--			
Blanket spray	--	--	--	X	X	X			
7. Acid lead arsenate (lbs.)	4	4	3	--	--	--	19.5	17.0	1.4
OrthoK NW Flowable (pts.)	1	1	8	--	--	--			
HiSpred casein spreader 5/ (ozs.)	8	4	--	--	--	--			
Blanket spray	--	--	--	X	X	X			

1/, 2/ California Spray Chemical Corporation.

3/, 4/ Leffingwell Company.

5/ Nico-Dust Manufacturing Company.

Analyzing of the strip solutions from pear samples taken from the trees of each lead arsenate spray schedule has been inadvertently delayed. Strips of the entire fruits have been prepared in triplicate for each treatment and, in addition, strips of the excised calyces only from other samples have been obtained.

C. Kelsey Plums, Stensgaard Orchard, Pomona

Because of the difficulty growers have experienced in controlling codling moth on Kelsey plums with basic lead arsenate, the spray schedules shown in Table 4 were tested this past season. Arsenicals and fluorine compounds can only be applied early in the season since washing of the fruits is prohibitive; hence careful timing of the sprays is required to prevent a build-up for a large second brood. Since the use of acid lead arsenate involved the likelihood of severe arsenical injury several corrective materials were tested with this insecticide. Hydrated lime appeared to safen the acid lead arsenate with a concomitant loss in toxicity to the larvae. In the presence of zinc, the injury from acid lead arsenate was greater than when it was used alone as in schedule 3.

Phenothiazine sprayed trees produced measureably larger fruits. DDT materials were effective and did not cause any apparent injury. It is probable that DDT would give much better control when used throughout a planting as most of the injuries on DDT sprayed trees resulted from second brood worms. Residue analyses indicate that there was practically no DDT residue on the plums during this period of codling moth attack. Xanthone (Genicide), not listed in Table 4, was applied at the rate of 2 pounds per hundred gallons of water in this field test but injuries to the fruit from these early applications were severe and the plums were not harvested.

Limited studies were made of the surface residues of DDT at harvest and of the possible penetration of DDT into plums. The results are summarized below:

Treatment	DDT residue in p.p.m. wet weight Surface deposit	 Within fruit 1/
Gesarol AK20 (5 lb.)	0.5 0.5	0.0
Gesarol AK20 (5 lb.) + Orthex (1 pt.)	0.0 0.0	0.0
Gesarol AK20 (5 lb.) + Colloidal "77" (4 oz.) + Light medium oil (1 qt.)	0.0 ---	0.0
Gesarol AK20 (10 lb.) + Orthex (1 pt.)	0.7 0.6	0.0

1/ Two factors make these penetration studies indefinite: (1) the intense red color of the final titration sample precluded exact determination of the end-points, and, (2) the samples were inadvertently dried at 80° C., instead of 65° C. and this temperature could have caused some decomposition of any DDT that may have been present.

TABLE 4. CODLING MOTH TEST ON KELSEY PLUMS, POMONA

Note: Spray applications May 8-10 and May 24-26. Harvest, August 26-28.

Materials per 100 gallons	Per cent		Average leaf drop per tree 1/	
	Wormy	Stung	June 8-12	June 12-20
1. Basic lead arsenate, 4 lbs.	12.2	4.2	15	169
2. Basic lead arsenate, 4 lbs. Orthex 2/, 1 pt.	6.7	3.9	6	45
3. Acid lead arsenate, 3 lbs. Orthex, 1 pt.	3.5	2.6	36	518
4. Acid lead arsenate, 3 lbs. Hydrated lime, 16 lbs, Orthex, 1 pt.	8.2	3.9	8	60
5. Acid lead arsenate, 3 lbs. Zinc sulfate monohydrate, 5 lbs. Hydrated lime, 8 lbs. Orthex, 1 pt.	6.4	2.7	191	1835
6. Acid lead arsenate, 3 lbs. Delmo-Z 3/ 1/2 lb. Orthex, 1 pt.	1.8	2.0	158	1554
7. Acid lead arsenate, 3 lbs. Safe-N-lead 4/, 1 lb. Orthex, 1 pt.	3.3	2.2	35	512
8. Cryolite 5/, 3 lbs. Orthex, 1 pt.	10.2	2.8	5	65
9. Black Leaf 155 6/, 3 lbs. Orthex, 1 pt.	7.4	2.8	16	76
10. He761 , 1 lb. Pyrax ABB, 4 lbs. Orthex, 1 pt.	5.9	3.0	8	29
11. Phenothiazine, 4 lbs. Orthex, 1 pt.	7.0	3.3	8	60
12. Gesarol SHN20, 1 qt. Blood albumin spreader, 2 oz.	5.4	2.0	13	107
13. Gesarol SHN20, 2 qts. Blood albumin spreader, 2 oz.	1.9	1.4	6	41
14. Gesarol AK20, 5 lbs.	2.7	1.2	10	66

TABLE 4. (CONTINUED)

Materials per 100 gallons	Per cent		Average leaf drop per tree 1/	
	Wormy	Stung	June 8-12	June 12-20
15. Gesarol AK20, 5 lbs. Orthex, 1 pt.	1.5	1.2	9	51
16. Gesarol AK20, 10 lbs. Orthex, 1 pt.	0.8	0.9	8	70
17. Gesarol AK20, 5 lbs. Colloidal "77" 7/, 4 oz. Light medium oil, 1 qt.	1.7	1.4	10	70

1/ Total number of leaves counted in area between circles described with radii 3 feet, and 5 feet from tree trunks.

2/, 3/ California Spray Chemical Corporation.

4/ Sherwin-Williams Company.

5/ Aluminum Company of America.

6/ Tobacco By-Products and Chemical Corporation, Inc.

7/ Colloidal Products Corporation.

CALIFORNIA (Continued)

A. E. Michelbacher, University of California, Berkeley.

CONTROL OF CODLING MOTH ON PAYNE VARIETY OF WALNUT

In our investigation on the control of the codling moth at Linden, best control was obtained where trees were sprayed twice with DDT. The first application was made May 9 and the second on June 26.

The composition of the first spray was as follows:

20 percent DDT (Geigy material with wetting agent)	5 pounds
Water	100 gallons

The composition of the second spray was:

20 percent DDT (Geigy material without wetting agent)	5 pounds
Blood albumin	4 ounces
Water	100 gallons

For the first spray the DDT was slowly added to the tank when it was one-half full of water while for the second the DDT and blood albumin were thoroughly mixed, then slurried and the mixture slowly added to the tank when one-half full. The sprays were applied with a Bean sprayer through a Meyer gun at a pressure of approximately 500 pounds. Thirty to thirty-five gallons were used per tree for the first spray, and from twenty to thirty-five gallons for the second.

Where the two sprays were applied, no infested nuts were found in the harvested crop. Where trees had only received one spray application on May 9, 0.9 of one percent of the nuts were infested. The degree of infestation in the harvested crop from the check trees was 18.63 percent.

A rather serious walnut aphid, Chromaphis juglandicola (Kltb.) infestation developed on the trees sprayed with DDT. This occurred despite the fact that DDT was effective in killing the pest. The spray also killed the predators. From observations it appeared that the DDT remained effective longer against the aphid predators than it did against the aphid. As a result the aphid had an opportunity to become established and built up a large population before the controlling influence of its predators and probably its parasites came into operation.

Standard lead arsenate with a safener was compared with basic lead arsenate. The former proved to be the most effective, although both materials gave very good control.

The composition of the sprays used in the tests was as follows:

Standard lead arsenate treatment

Standard lead arsenate	3 pounds
Delmo Z (a commercial basic zinc-sulfate product which is used as a safener for standard lead arsenate and which contains 50 percent zinc expressed as metallic)	1 pound
A liquid spreader and sticker	1/2 pint
Medium soluble oil	1/3 gallon
Water	100 gallons

Order of mixing: standard lead arsenate and Delmo Z slurried and added to tank when water was about up to agitator rod, spreader added immediately after this, and the oil added when the tank was 2/3 to 3/4 full.

Basic lead arsenate treatment

Basic lead arsenate	4 pounds
Medium soluble oil	1/3 gallon
Spreader (W7)	2 2/3 ounces
Water	100 gallons

Order of mixing: oil, spreader and lead.

For best control two sprays were necessary; one to take care of the first brood and a second to control the second brood. Where standard lead arsenate was applied on May 1 and May 29, 1.26 percent of the nuts in the harvested crop were infested. The basic lead arsenate treatment that gave best control was where the first spray was applied on May 1 and the second on May 18. With this treatment 1.41 percent of the nuts in the harvested crop were infested.

Other basic lead arsenate treatments studied were as follows:

Sprayed once ...... May 1

Sprayed once ...... May 29

Sprayed twice ..... May 1 and 29

Sprayed twice ..... May 1 and June 26

A summary of the results obtained with the standard and basic lead arsenate treatments is given in Table 1. Each treatment was replicated 7 times in a Latin square.

Table 1: Comparison of Several Spray Treatments in Controlling Codling Moth in the Harvested Walnut Crop

Treatment and date of application	Percent infested			Percent	Percent
	Good*	Culls**	Total infested	Culls other than infested	Good Nuts
Check	9.62	3.37	13.00	6.00	80.99
Basic lead arsenate May 1	2.84	1.11	3.96	7.81	88.22
Basic lead arsenate May 29	4.68	2.61	7.29	7.69	85.00
Basic lead arsenate May 1 and 18	0.98	0.43	1.41	8.62	89.96
Basic lead arsenate May 1 and 29	1.62	0.68	2.30	9.79	87.89
Basic lead arsenate May 1 and June 26	1.67	0.86	2.53	8.88	88.57
Standard lead arsenate May 1 and 29	0.86	0.40	1.26	8.00	90.73

* Nuts rendered culls due to worms.

** Nuts attacked by worms but would have been classed as culls to other causes.

Although the information given in Table 1 clearly shows the relative effectiveness of the various spray treatments in reducing the number of infested nuts in the harvested crop, it does not, however, show to what degree the nut crop was protected by the treatments. This is because early infested nuts usually fall prematurely and thus are not registered in the harvested crop. The effectiveness of treatment is best shown in figure 1 where total good nuts, infested nuts and culls other than infested in the harvested crop are plotted. This shows that the yield of good nuts for the check trees falls far short of that of any of the spray treatments.

Investigation work on the control of the codling moth was undertaken in the Sacramento Valley at Gridley. Poor control was obtained with the basic lead arsenate treatment that proved effective at Linden. An investigation as to the reason for this revealed that in the harvested crop a very large proportion of the infested nuts were infested by the Catalina cherry moth, Melissopus latiferreanus. This infestation apparently set in very late in the season, as in the harvested crop many nuts with very small caterpillars were encountered.

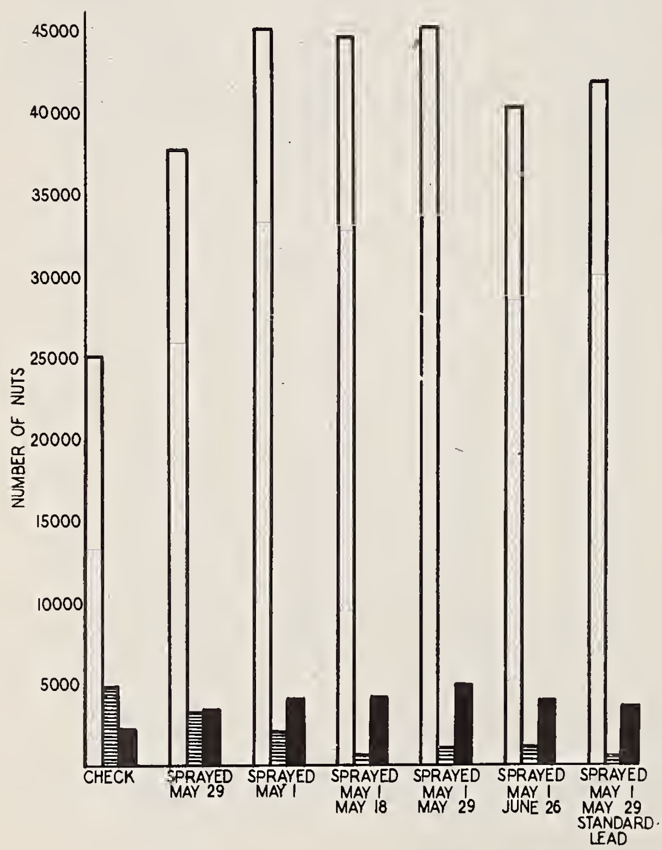

Fig. 1. Total harvested nuts from each treatment classified as good, infested, and culls other than infested. Open bar, good; Horizontal hatched bar, infested; Solid bar, culls other than infested.

COLORADO

Geo. M. List, Colorado Agricultural Experiment Station, Fort Collins and J. H. Newton, Bureau of Plant and Insect Control, Paonia.

Seasonal Conditions and Control Experiments

The apple and pear crop was light in most fruit growing areas of the State. This condition, coupled with a favorable season for codling moth developments, made the control problem difficult.

In addition to the usual service of assisting the growers to establish spray dates a series of control tests on pear and apples was conducted at Clifton the Colorado Experiment Station and Bureau of Plant and Insect Control cooperating.

Control Experiments on Bartlett Pears, M. L. Dilley Orchard

The experimental set-up consisted of 12 spray schedules replicated six times in 72 double tree randomized plots. The trees were of moderate size with slightly more than half a crop. The data from one tree of each plot are presented:

Spraying Dates Established for the Season

First Brood Sprays		Second Brood Sprays	
Calyx spray	May 16-17		
1st cover spray	May 24-25	5th cover spray	July 7-8
2nd cover spray	June 2-3	6th cover spray	July 20-21
3rd cover spray	June 9-10	7th cover spray	July 30-31
4th cover spray	June 19-20	8th cover spray	Aug. 12-13

Spray Schedules 1/

No. 0: Gesarol, known technically as dichloro-diphenyl-trichloroethane and to the layman under the initials DDT, were used in schedules Nos. 0 and 10. In schedule No. 0 the calyx and first cover spray consisted of DDT (A-20) at the rate of 2 pounds per 100 gallons, while in the remaining cover sprays the DDT (AKZ-20) was used at the rate of 3 pounds to 100 gallons plus 3 ounces of Eriopon as an adhesive and spreading agent.

1/ Calyx spray in all plots except No. 0 consisted of lead arsenate 3 pounds to 100 gallons of water.

Spray Schedules 1/ (Continued)

No. 1: This is known locally as the standard lead arsenate-kerosene-soap modified dynamite or inverted spray mixture, which builds up a uniform spray deposit when applied with sufficient pressure and quantity. The mixture consists of lead arsenate 3 pounds to 100 gallons, plus kerosene 2 quarts and liquid soap 1 pint. In the second, third and fifth cover sprays the kerosene was reduced to 1 pint with the addition of 2 quarts of summer oil (Superla) as an ovicide at the peak of egg deposition.

No. 2: The same schedule and spray mixture as in No. 1 except that (B-1956) was used as the emulsifying agent in the place of the liquid soap. This produced a smooth spray deposit but did not build a heavy deposit as in the case of the lead arsenate-kerosene-soap mixture.

No. 3: A split schedule using the standard lead arsenate-kerosene-soap mixture as in schedule No. 1 through the first brood sprays. Second brood spray consisted of lead arsenate 3 pounds to 100 gallons plus Black Leaf 155, 2 pounds to 100 gallons. (No oil.)

No. 4: A split schedule using the standard arsenate of lead-kerosene-soap mixture as in schedule No. 1, for the first brood sprays. Second brood sprays consisted of B. L. 155, 2 pounds to 100 gallons plus 1 quart of summer oil (Superla). As an ovicide the oil was increased to 2 quarts in the sixth cover spray.

No. 5: Eight cover sprays of B. L. 155, 2 pounds to 100 gallons plus summer oil (Superla) 1 quart. The oil was increased to 2 quarts in the second, third and sixth cover sprays.

No. 6: Lead arsenate (Sherwin Williams) red label, 3 pounds to 100 gallons plus Spralastic, 1 1/2 pints for the first cover spray, 1 quart in the second and third covers, and then reduced to 1 1/2 pints in the fourth cover and to 1 pint in the fifth to eighth cover sprays inclusive.

No. 7: Black Leaf 155, 2 pounds to 100 gallons plus 2 quarts of summer oil (Superla) applied at the rate of 10 to 12 gallons per tree per application throughout the season. Eight cover sprays of heavy application.

No. 8: The same as No. 7, except that the rate of application was moderate, being 6 to 8 gallons per tree per application for eight cover sprays.

No. 9: A modification of schedule No. 1, which consisted of lead arsenate 3 pounds to 100 gallons plus 2/3 pint of liquid soap, kerosene 2 quarts and 1 quart of summer oil (Superla). The kerosene and summer oil were made into a stock solution of 2 to 1. This mixture, known locally as Pond's mix, gave a very nice smooth deposit.

1/ Calyx spray in all plots except No. 0 consisted of lead arsenate 3 pounds to 100 gallons of water.

Spray Schedules 1/ (Continued)

No. 10: Lead arsenate and DDT split schedule. First brood sprays same as in No. 1. Second brood sprays consisted of Gesarol (DDT) AK-20, 3 pounds plus 3 ounces of Eriopon as adhesive and spreading agent.

No. 11: Standard schedule same as No. 1 except the summer oil was (Socony) instead of (Superla).

1/ Calyx spray in all plots except No. 0 consisted of lead arsenate 3 pounds to 100 gallons of water.

Note: DDT (A-20), (AK-20) and (AKZ-20) refer to preparations of DDT containing 20 percent of the active ingredient. Accordingly the amounts of active ingredient (DDT) used per 100 gallons of spray solution were 0.4 to 0.6 of a pound.

Table I. Summary of Codling Moth Control. Bartlett Pears. Six single tree replicates of 12 different spraying schedules. Season 1944. Dilley orchard, Clifton, Colorado.

Schedule	Total Wind-falls	Percent Windfalls Wormy	Total Fruit Har-vested	Total Harvest Fruit Scored	Percent of Harvest Fruit			
					Sound	Injured	Wormy	Stung Only
0	467	65	5549	1664	76	24	5	19
1	2281	98	1324	600	54	46	41	5
2	2995	98	2464	800	35	65	61	4
3	2155	98	2524	750	43	57	51	6
4	2117	96	2999	1050	64	36	28	8
5	2761	94	3931	1250	70	30	25	5
6	3008	96	1777	600	34	66	57	9
7	1043	86	4219	1250	82	18	17	1
8	1449	93	4396	1250	83	17	15	2
9	2611	94	2187	650	41	59	51	8
10	1297	91	3337	1150	76	24	13	11
11	2800	97	2818	750	44	56	49	7

Table I. (Continued)

Schedule	Total Fruits	Percent Season's Fruits Dropped - Wormy	No. Injuries per 100 Fruits			Average Weight per Fruit in oz. 1/
			Total	Worms	Stings	
0	6016	5	28	5	23	3.84
1	3605	60	63	55	8	4.19
2	5459	54	114	103	11	3.96
3	4679	46	90	79	11	3.50
4	5116	39	48	36	12	4.55
5	6692	33	38	32	6	4.85
6	4785	61	108	91	17	3.54
7	5262	17	26	21	5	4.23
8	5845	21	21	18	3	4.29
9	4798	50	102	87	15	4.18
10	4634	23	38	18	20	4.21
11	5618	48	79	62	17	4.03

1/ Two lots of 50 pears each weighed from each single tree replicate.

Control Experiments on Winesap Apples, M. L. Dilley Orchard

The experiment included three treatments:

(1) Lead arsenate 3 pounds, kerosene 2 quarts, and liquid soap 1 pint to 100 gallons of water. This corresponds with No. 1 used on pears.

(2) Gesarol A-20 two pounds to 100 in calyx and 1st cover applications. Gesarol AK-20 two pounds, Superla oil 2 quarts to 100 in 2nd, 3rd, and 4th cover applications. The AK-20 was increased to 3 pounds to 100 in the 5th, 6th, 7th, and 8th cover sprays.

(3) Gesarol A-20 three pounds per 100 gallons in calyx and first three cover sprays. AKZ - 2 pounds Eriopon spreader, 2 ounces to 100 in 4th cover, and AKZ - 3 pounds, Eriopon spreader 3 ounces to 100 in 5th to 8th cover sprays inclusive.

The spray dates were the same as given for the pear experiment. Each treatment was replicated six times on randomized single tree plots. No record was taken of the windfall fruits.

The following data are based on the examination of 500 fruits from each plot at harvest.

Table II. Summary of Codling Moth Control. Winesap Apples. Six Single Tree Replicates.

Treatments	Percent Fruit			
	Sound	Injured		
		Total	Wormy	Stung
1. Lead arsenate 3 lb. to 100	54.6	45.3	14.0	31.3
2. Gesarol AK-20	67.2	33.1	4.1	29.0
3. Gesarol AKZ-20	53.5	46.5	9.5	37.0

DELAWARE

D. O. Wolfenbarger, Delaware Agricultural Experiment Station, Newark.

Tests in 1944 were made on a very small scale in the College Orchard at Newark, where the codling moth infestations are usually not severe. The trees were Blaxtaymen, 8 years old, with a moderately large crop. All trees in the tests were treated similarly until the first cover spray, at which point different treatments were imposed. A tabulation of the treatments and results follows:

Treatment	Worms per 100 Apples	Stings per 100 Apples
Lead arsenate 4 lb., lime 5 lb., water 100 gal.	1.5	12.8
DDT (Gesarol) 4 lb. (0.8 lb. of DDT), water 100 gal.	1.8	10.0
Above were hand sprayed.		
Check - no cover spray	20.0	9.1
Regular Farm Schedule (machine sprayed)	1.0	5.5
There was no burning of any fruit.		

Seven cover sprays were applied to all trees treated, except the check, which had none. Nicotine sulfate was used in the Regular Farm Schedule May 29, June 7, and July 18, and summer oil was used May 29 and June 7.

Additional observations with reference to DDT are given as follows:

Source of material - Gesarol A20
Effect on foliage - apparently none
Effect on pollinators, predators, mites - none observed
Influence on abundance of mites, aphids, etc. - some rosy apple aphis observed on DDT, more than on other trees, although not counted; more symptoms of European red mite injury, injurious effects were marked, even compared to unsprayed trees.

GEORGIA

W. H. Clarke, Fruit Pest and Parasite Laboratory, Georgia Department of Entomology, Cornelia.

1. Seasonal Conditions and Status of Codling Moth Infestations during 1943.

Spring brood emergence of moths was the lightest recorded in several years. A very light crop of fruit on the Delicious trees where a portion of the traps were located no doubt affected the total catch, and unfavorable weather reduced moth flight. Total catch for the season was 273 moths. Peak catches occurred on June 30 and July 24 for later broods.

2. Studies on codling moth biology and behavior.

Weekly collections of stung apples were made in an abandoned orchard and records taken on emergence of moths and parasites. The parasite emergence was the lowest recorded in the last four seasons with the only parasite of importance recovered being the larval parasite *Ascogaster carpocapsae*.

3. Parasitism of codling moth eggs.

Collections of codling moth eggs in the field during the early part of July showed the *Trichogramma minutum* parasite responsible for parasitism of an average of 8.2 percent of codling moth eggs. These records are for abandoned orchards where no parasite colonizations had been made for several years.

4. Availability of insecticides and equipment.

Insecticides were available but there were some reports of delays in obtaining needed equipment.

ILLINOIS

S. C. Chandler, Illinois Natural History Survey, Carbondale.

I. Seasonal conditions and status of codling moth infestation during 1944.

This season, as it affected codling moth, was very similar to that of 1943 in Illinois. Rains early in the season tended to hold down a heavy carry-over, but a severe drouth from mid-June on made conditions so favorable that early checks were offset and by harvest the heaviest infestation we have had in years had developed. This was brought out in the Codling Moth Survey, a study of certain orchards over a three-year period. The average percent of apples wormy in first brood was 1ppercent and at harvest 20 percent. Damage in certain orchards increased in a much greater ratio, and in one orchard wormy apples increased 113 times from first brood to harvest.

II. Studies of codling moth biology and behavior.

This phase of the study consisted of emergence cage, bait trap and light trap records kept at a large number of points over the state, for the primary purpose of assisting in timing sprays. Of biological interest was the shorter period between petal fall and first serious hatch and "bunching" of first brood emergence in May, before growers were prepared to use summer oil, and also the occurrence (as indicated also in the records at Vincennes) of a partial fourth brood in the southern end of the state.

III. Results of control experiments.

1. Dormant eradicant tests. A block of old Winesap and Delicious, 35 trees long by 29 trees wide, was sprayed in March with dinitro-o-cresol and oil on the trunks and main branches and for two or three feet out from the trunk on the ground. The following two combinations were on the trees:

A. DNC, 4 lb.; fuel oil, 10 gal.; fish oil soap, 4 lb.; to 100 gal. water

B. DNC, 4 lb.; Dendrol 6 gallons

These trees, over 25 years old, required six gallons per tree, and a very thorough application was made every inch being wet. Examinations made from time to time showed a maximum of 71 percent of the larvae killed. In most cases where the material penetrated behind the bark sufficiently to thoroughly wet the cocoons, the larvae were dead, but penetration was not always effected. It is possible that this was a too severe test, as

there were many larvae cocooned in spots where access by any material was difficult. Be that as it may, the original plan to eradicate the insect in a large block so that a greatly reduced spray schedule could be followed had to be abandoned, as it soon became evident in the spring that a very heavy infestation was in the making. Some injury occurred to lower hanging terminals that were hit by the DNC mixture, but this was not extensive enough to have been considered serious if the eradication test had been successful.

2. Spraying tests during growing season.

A. Small Plot Tests, Grafton. These tests were conducted in cooperation with the University of Illinois, Department of Horticulture, and were designed primarily for the study of fungicides, spray injury and compatability of certain insecticides and fungicides, but provided certain information on codling moth control which served as a check on some of the large-scale plots.

These plots were on two varieties, Jonathan and Gano, and were duplicated, in each. Size of plots was 3 rows wide by 5 to 10 rows long.

A lead-lime and a lead-weak Bordeaux schedule were used in comparison with the factory-mixed nicotine, Black Leaf 155, at 1 1/2 pounds to 100 gallons, used at weekly intervals except between broods.

B. Large Plot Tests, Grafton. The object of these tests was to study codling moth control obtained by the use of certain recognized and recommended spray schedules and materials in large plots in the same orchard. They were located in the same 72-acre block in which the above small plot tests were placed. The orchard had been very heavily infested in 1943. Orchard sanitation had been neglected, and the heavy infestation at harvest was the result of these factors and a very favorable season for the development of the insect from June on. The plots were 12 trees square, making over four acres in each. They were over 25 years old. The plots were arranged so that there were six rows of Jonathans and six of Ganos in each.

In the first brood all plots received a calyx, three full covers, and two topoff sprays, making a total of six, at weekly intervals. In the second brood all lead plots received three sprays on Jonathans and four on Ganos, making a total of 9 and 10 applications. Of the nicotine plots all except two received four second brood sprays on Jonathans

and five on Ganos, making a total of 11 and 12 for the season. The plots sprayed with Nicosol and B. L. 155 at 1 1/2 pounds received five sprays on Jonathans and six on Ganos, making a total of 11 and 12 applications. These two were sprayed at weekly intervals during the second brood. The "split" schedule referred to below was one in which lead arsenate was used in the calyx and first four covers, with B. L. 155 in the third and fourth at half strength and at full strength without the lead arsenate from that application. In all plots, lead arsenate was used in the calyx, calyx topoff, and first cover sprays, the nicotine plots starting from that point on. Summer oil was used with nicotine at the rate of two quarts per 100 gallons in all applications. Nicosol was used at three quarts per 100 gallons. Summer oil was used with lead arsenate where called for in the Illinois spray schedule, in this case in five applications. Final infestation counts on picked fruit are summarized below:

Final Infestation Counts, Codling Moth, Summarized and Grouped According to Treatment

Variety--Jonathan

Treatment	Plot No. 1/	Percent Wormy	Percent Stung	Total Blemishes per 100 Apples
Lead-Lime	13 Small Plots	70.7 54.9	19.5 30.6	597
Lead Wk. Bord.	16 Small Plots	35.0 41.3	43.6 37.3	
BL 155 - 1 1/2 lb.	12 Small Plots	29.1 35.6	21.6 19.8	156
Tank Mix Nic. Bent.	18	39.3	18.2	
Nicosol	19	63.9	15.8	
BL 155 - 3 lb.	20	46.4	19.2	109
Split	21	36.1	26.4	167
Check	11	84.4	4.0	

1/ Data refer to the large-plot tests unless otherwise indicated.

Final Infestation Counts, Codling Moth, Summarized and Grouped According to Treatment (Cont'd)

Variety--Gano

Treatment	Plot No. 1/	Percent Wormy	Percent Stung	Total Blemishes per 100 Apples
Lead-Lime	13	74.2	25.0	1623
	Small Plots	45.3	41.7	
	16	58.4	38.2	1024
Lead-Weak	22(Speed)	34.9	53.2	
Bordeaux	23(Conventional)	48.1	43.5	
	Small Plots	31.9	44.4	
BL 155 -	12	40.4	37.8	247
1 1/2 lb.	Small Plots	30.2	24.9	
Tank Mix Nic. Bent.	18	47.2	32.6	275
Nicosol	19	77.4	19.4	496
BL 155 - 3 lb.	20	46.6	39.8	365
Split	21	69.0	25.0	527
Check	11	92.6	1.6	

1/ Data refer to the large-plot tests unless otherwise indicated.

In this table it is probable that the relatively higher percent of wormy fruit in the lead-nicotine "split" schedule, Plot 21, on Gano was due to the small crop on Gano trees in that plot and that the Jonathan records are more comparable with the other blocks.

These tests bring out the following:

1. Under conditions of a very heavy carry-over and insufficient orchard sanitation, coupled with a favorable season for development of the insect, no schedule may give commercial control.

2. Lead-weak Bordeaux was superior to lead-lime. This was true not only in insect control, but also in foliage injury.

3. Nicotines in general were more efficient than lead arsenate in a season like this, hot and dry. This was true in control and in condition of foliage and fruit.

4. Nicosol was inferior to other nicotines used.

5. Black Leaf 155 applied at shorter intervals, even though reduced in amount per 100 gallons, was superior under these heavy infestations to the same material at a longer interval between sprays.

C. Speed Sprayer Tests, Grafton. The so called "speed sprayer" was compared on Ganos in the same orchard with what we called the conventional method. In this orchard conventional spraying was done with a 500-gallon sprayer, with a 35-gallon-a-minute pump, power take-off, with one man spraying from the tower and one from the rear platform, using a non-stop system.

The following data were collected during the season:

1. Time required. In six applications the average showed the following number of minutes for each method, to spray out 500 gallons of material:

	Spray	Fill tank	Total
Speed Sprayer	12.8	9.2	20.0
Conventional	21.0	14.8	35.8

Three men on the conventional rig (including tractor driver) did in 35.8 minutes what two men on the speed sprayer (including one to operate conveyor) did in 20 minutes.

2. Gallons used per tree. The average of six applications was 11.8 gallons per tree for the speed sprayer and 13.6 for the conventional.

3. Infestation and deposit in tops of trees. Counts made during June showed that there were from four to eight times as many wormy apples in the tops as in the lower parts of the trees in both blocks. Ratio of deposit based on averages of analyses made at various times throughout the season showed the following ratios in tops and bottoms.

Speed sprayer 1 to 1.8

Conventional 1 to 1.7

4. Penetration into tree. Apples from the lower parts of the trees were analyzed with the outside half, toward the sprayer, separate from the inner half, toward the trunk of the tree with the following results:

Ratio of "inside" and "outside" halves of apples:

Speed sprayer	1 to 1.3
Conventional	1 to 1.9

This would indicate a slightly greater coverage on the insides of the tree with the speed sprayer than with the conventional system.

Percentage of total codling moth injuries on the outer half of the apple was approximately the same, 64 percent and 65 percent, as compared with 75 percent on the checks.

5. Final infestation at harvest is shown in the table, being slightly greater in the conventional system, 58 percent and 35 percent wormy.

D. Use of Safener with Lead Arsenate, Carbondale. Safe-N-Lead, a zinc oxide safener manufactured by the Sherwin Williams Company, was compared with lime on Jonathans, in the calyx and five cover sprays. At final checking, 27.5 percent of the apples sprayed with Safe-N-Lead showed calyx injury, compared with 4.2 percent in the block safened by lime. Infestation showed 26 percent wormy in Safe-N-Lead and 31 percent in the lime plot. The ratio of approximately six to one on safening effect of this material may possibly have been due in part to use of Fermate in the lime plot. In 1943, tests in the same place where there were no other possible factors showed a ratio of two and one-half to one in favor of lime over Safe-N-Lead.

E. Codling Moth Survey. For three years a study of the factors affecting codling moth control has been conducted in 13 representative orchards located in the three-brooded area in southern Illinois. In a year when lead arsenate was less efficient than nicotine because of hot, dry weather, it was found that the two lowest infested orchards of the 13, with an average of 3 percent wormy fruit or less at harvest, depended chiefly or entirely on lead arsenate. Of the four heaviest infested orchards, in which the harvest infestations ranged from 15 percent to 85 percent wormy, two received lead arsenate and two a combination of lead and nicotine, chiefly the latter. The greatest differences in methods between the successful growers and the unsuccessful is not in materials nor in any certain system of spraying, but rather in the methods taken to reduce carry-over. The most successful growers pruned and opened up the trees so spray material could reach all parts of the trees. They were careful sprayers. They used sufficient material, but not by any means excessive amounts. They consistently practiced orchard sanitation, including thorough scraping and banding.

ILLINOIS (Continued)

M. D. Farrar, Illinois Natural History Survey, Urbana.

In the control of codling moth, data indicate that mixtures containing DDT will control this insect as well as lead arsenate or nicotine and in some cases better than either of the latter two materials.

The DDT was applied in dry powdered form and as an emulsion in liquid form. Both methods resulted in high quality fruit, excellent foliage, and satisfactory control of codling moth and leafhoppers. The mites, although not a factor in the experiments, were more abundant on plots sprayed with DDT than on plots sprayed with lead arsenate.

One year's trials with this chemical show that it must be used at about the same spray interval as other spray materials. The fact that codling moth can destroy fruit sprayed with DDT is clearly shown in Tables I and II, which show the codling moth damage in these plots up to September 18. The relative standing of the plots at this time did not change materially at harvest time.

Table III shows the over-all condition of fruit and foliage in the plot at harvest. With the exception of the mite populations in the DDT sprayed plots, these plots were superior in all other respects to the plots sprayed with lead

Codling Moth Control on Winesap Apples in Experimental DDT Plots, Urbana, Illinois, 1944

Table I.

Plot No.	Treatment six cover sprays	Crop in Bushels	Condition of Dropped Fruit on 9/18/44			Total C. M. Injury to Crop at Harvest	
			Crop on Ground	Drops Wormy	Drops Stung	Wormy	Stung
			%	%	%	%	%
1.	Standard Lead Arsenate	5.5	1.9	25.0	22.0	4.4	21.8
2	1# DDT, 9# Pyrax, 2 qt. Summer oil	13.0	1.3	26.7	4.0	3.1	3.8
3	1/2# DDT, 4 1/2# Pyrax, 2 qt. Summer oil	7.5	2.6	69.0	1.3	11.5	6.4
4	1/4# DDT, 2 1/4# Pyrax, 2 qt. Summer oil	7.5	5.2	54.0	3.4	11.0	7.4
5	1/4# DDT, 2 1/4# Pyrax, 2 lb. Lead Ars., 2 qt. Summer oil	13.0	2.0	21.0	12.3	3.1	9.7
6	0.1% DDT in a 1% S. oil	6.0	12.8	64.8	6.3	26.6	9.7
7	Control - no sprays	7.0	36.6	98.7	0.8	75.4	10.0
8	Standard Lead Arsenate	4.5	7.8	55.3	26.2	12.4	38.9

Codling Moth Control on Winesap Apples in Experimental DDT Plots, Urbana, Illinois, 1944

Table II.

Plot No.	Treatment same as Table I for two covers--third cover omitted. Materials listed were used in last three cover sprays	Crop in Bushels	Condition of Dropped Fruit on 9/18/44: Crop on Ground	Condition of Dropped Fruit on 9/18/44: Drops Wormy	Condition of Dropped Fruit on 9/18/44: Drops Stung	Total C. M. Injury to Crop at Harvest: Wormy	Total C. M. Injury to Crop at Harvest: Stung
			%	%	%	%	%
1	Standard lead arsenate	8.0	4.8	53.9	11.5	15.9	26.7
2	1# DDT in emulsion, 2 qt. Summer oil	14.0	4.7	67.6	3.9	10.3	8.2
3	1/2# DDT in emulsion, 2 qt. Summer oil	16.0	4.3	56.0	2.5	5.5	14.2
4	1/4# DDT in emulsion, 2 qt. Summer oil	12.0	5.9	71.6	5.1	24.3	11.6
5	1/4# DDT in emulsion, 2 lb lead ars., 2 qt. S. oil	9.0	7.3	25.1	11.3	8.8	14.4
6	0.1% DDT in 1% Summer oil	6.0	20.5	78.7	3.9	41.0	12.6
7	Control - no sprays	6.0	43.5	98.2	0.9	79.8	7.3
8	Standard lead arsenate	1.0	13.6	74.5	15.6	23.0	40.9

Conditions Observed on Winesap Apples in Experimental DDT Plots, Urbana, Illinois, 1944

Table III.

Plot No.	Finish of Fruit	Condition of Foliage	Abundance of Mites	Abundance of Leafhoppers
1	Fair	Fair	None	Moderate
2	Excellent	Excellent	Heavy	None
3	Excellent	Excellent	Moderate to Heavy	None
4	Excellent	Excellent	Light	None
5	Excellent	Moderate leaf burn	Trace	Very light
6	Excellent	Moderate leaf burn	Trace	Very light
7	Good	Fair	None	Moderate to Heavy
8	Good	Fair	None	Moderate to Heavy

INDIANA

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CODLING MOTH CONTROL STUDIES IN INDIANA FOR 1944

The plot studies at the Purdue Entomological Experimental Orchard, as in recent years, are of treatments never before tried in the field and include the three varieties Grimes, Delicious and Winesap. Two single tree plots of each of the varieties have been included in each treatment making a total of six replicates.

The plot containing talcum did not clean well in the washing tests so further studies of this treatment will be abandoned, however, all the other schedules resulted in very good foliage at harvest and at the present time there seems to be no difficulties involved in removal of unsightly residue.

Fruit ripening was delayed somewhat in the case of plots five, six and eight. However, the foliage on these same plots was especially fine at the time of Winesap harvest October 16 and even until after the first hard freeze.

The results in tabular form follow:

PURDUE ENTOMOLOGICAL EXPERIMENTAL ORCHARD - 1944
APPLE SPRAY PLOT TREATMENTS FOR
CODLING MOTH CONTROL

PLOT	COVER SPRAYS	Treatments	DATE OF SPRAYS	JUNE 27 ALL VAR. W	JUNE 27 ALL VAR. S	HARVEST ALL VAR. W	HARVEST ALL VAR. S	HARVEST ALL VAR. AFF.
1	1-4	3# KG, 1 pt. N	May 18	4.1	13.8	Plots discontinued and 30 to 40 per cent of crop thinned off as wormy fruits -- July 22 - 25		
	5	1/2 gal. MO, 1/2# S, 4# LA	May 25					
	6	*5# MB, 2/3 pt. N, 1qt. SBO,1 pt. SD	June 8					
	7	1 pt. N, 1 qt. SBO,enough MB to emulsify the oil	June 29 July 22 Aug. 18 Sept.11					
2	1-4	3# KXS, 1 pt. N	May 18	4.2	19.7			
	5	1/2 gal. MO, 1/2# S, 4# LA	May 25					
	6	*5# MB, 2/3 pt. N, SBO, 1 pt. SD	June 8					
	7	1 pt. N, 1 qt. MO, enough MB to emulsify the oil	July 29 July 22 Aug. 18 Sept.11					
3	1-4	3# KOS, 1 pt. N	May 18	5.5	7.1			
	5	1/2 gal. MO, 1/2# S, 4# LA	May 25					
	6	*5# MB, 2/3 pt. N, 1 qt. SBO,1 pt.SD	June 8					
	7	1 pt. N, 1 qt. SBO,enough MB to emulsify the oil	June 29 July 22 Aug. 18 Sept.11					

*on all varieties except Winesap

PURDUE ENTOMOLOGICAL EXPERIMENTAL ORCHARD - 1944
APPLE SPRAY PLOT TREATMENTS FOR
CODLING MOTH CONTROL

Plot	Cover Sprays	Treatments	Date of Sprays		June 27 All Var. W	June 27 All Var. S	Harvest All Var. W	Harvest All Var. S	Aff.
4	1	3# LA, 1 1/4# F	May	18	.5	3.8	46.50	32.60	49.60
	2-5	5# WB, 1 pt. N, 1 qt. SBO	May	25					
	6	*5# MB, 2/3 pt. N, 1 qt. SBO, 1 pt. SD	June	8					
	7	1 pt. N, 1 qt. SBO, enough MB to emulsify	June	30					
		the oil	July	31					
			Aug.	18					
			Sept.	11					
5	1	3# LA, 1 1/4# F	May	18	.5	2.3	16.62	15.25	23.72
	2	9# WB, 1# ALC, 1qt. BL40, 2 qts. SBO,	May	25					
		1.1# S, 1# GC	June	8					
	3-4	9# WB, 14.5 oz. $ALSO_4$, 1 qt. BL40, 2 qts	July	1					
		SBO, 2 1/2# S, 1 3/4# GC	July	31					
	5	8# MB, 1 pt. N, 1/2 gal. SBO	Aug.	18					
	6	*5# WB, 2/3 pt. N. 1 qt. SBO, 1 pt. SD	Sept.	11					
	7	1 pt. N, 1 qt. SBO, enough MB to emulsify the oil							
6	1	3# LA, 1 1/4# F	May	18	1.3	2.3	18.07	22.05	30.50
	2	9# WB, 1# ALC, 1 qt. BL40, 2 qts. SBO	May	25					
		1.1# S, 1# GC	June	8					
	3-4	9# WB, 14.5 oz. $ALSO_4$, 1 qt. BL40, 2 qts.	July	1					
		SBO, 2 1/2# S, 14 oz. GC	July	31					
	5	8# WB, 1 pt. N, 1/2 gal. SBO	Aug.	18					
	6	*5# MB, 2/3 pt. N, 1 qt. SBO, 1 pt. SD	Sept.	11					
	7	1 pt. N, 1 qt. SBO, enough MB to emulsify							
		the oil							

*Or all varieties except Winesap

PURDUE ENTOMOLOGICAL EXPERIMENTAL ORCHARD - 1944
APPLE SPRAY PLOT TREATMENTS FOR
CODLING MOTH CONTROL

Plot	Cover Sprays	Treatments	Date of Sprays	June 27 all var. W	June 27 all var. S	Harvest all var. W	Harvest all var. S	AFF.
7	1	3# LA, 1 1/4# F.	May 18	6.6	9.1	30.74	46.60	45.37
	2	9# T, 1# ALC, 1 qt. BL40, 1 1/2 qt.SBO,	May 26					
		11 oz. GC, 8 1/2 oz. S	June 9					
	3-4	10 1/8# T, 1# 1/2 oz. $ALSO_4$, 1 qt. BL40	July 14					
		2 qts. SBO, 1 7/8# GC, 1# 14 oz. S**	July 31					
	5	8# MB, 1 pt. N, 1/2 Gal. SBO	Aug. 18					
	6	*5# MB, 2/3 pt. N, 1 qt. SBO, 1 pt. SD	Sept.11					
	7	1 pt. N, 1 qt. SBO, enough MB to emulsify the oil						
8	1	3# LA, 1 1/4# F.	May 18	.2	2.0	11.47	26.87	33.97
	2	10# WB, 1# $ALSO_4$, 1 qt. BL40, 1 1/2 qts. SBO	May 25					
		9 oz. S, 3/4# GC	June 9					
	3-4	10 1/8# WB, 1# $ALSO_4$, 1 qt. BL40, 2 qts.	July 14					
		SBO, 1# 6 1/4 oz. S, 1 7/8# GC	July 31					
	5	8# MB, 1 pt. N, 1/2 gal. SBO	Aug. 18					
	6	*5# MB, 2/3 pt. N, 1 qt. SBO, 1 pt. SD	Sept.11					
	7	1 pt. N, 1 qt. SBO, enough MB to emulsify the oil						

*On all varieties except Winesap

**1# 6 1/4 oz. soap for 4th cover spray

PURDUE ENTOMOLOGICAL EXPERIMENTAL ORCHARD - 1944
APPLE SPRAY PLOT TREATMENTS FOR
CODLING MOTH CONTROL

Plot	Cover Sprays	Treatments	Date of Sprays	June 27 All Var.		Harvest All Var.		
				W	S	W	S	Aff.
9	1	3# LA, 1 1/4# F	May 18	.7	4.5	32.10	80.35	54.37
	2	10# 77, 1# $ALSO_4$, 1 qt. BL40, 1 1/2 qts. SBO	May 26					
		9 oz. S	June 9					
	3-5	10 1/8# 77, 1# $ALSO_4$, 1 qt. BL40, 2 qts. SBO	July 1					
		1# 6 1/4 oz. S	Aug. 2					
	6	*5# MB, 2/3 pt. N, 1 qt. SBO, 1 pt. SD	Aug. 18					
	7	1 pt. N, 1 qt. SBO, enough MB to emulsify the oil	Sept. 11					

*On all varieties except Winesap

KG -- Kolofog
BL40 - Black Leaf 40 (nicotine)
KXS -- Kolofix Special No. 1159
KOS -- Kolofix Special No. 491
WB -- Wyoming Bentonite
SBO - Soy Bean Oil
S - Soap
$ALSO_4$ - Aluminum Sulphate

T -- Talcum
77 -- Colloidol "77"
MS -- Pittsburg Plate Glass Co. - micronized sulphur
MO -- Mineral Oil
(for Elrods) - 302 gulf oil before June 15, then Latis 15 oil
(for expt.) - Ortho Ready Mix Oil
LA -- Lead Arsenic
L -- Lime
ZNSO4 -- Zinc Sulphate ($ZNSO_4$)
F -- Fermate
ALC. -- Aluminum Choride
GC -- A commercially prepared material suggested for use to prevent the rapid release of nicotine
SD -- Stop Drop
MB -- Mississippi Bentonite

The codling moth control plots at the Elrod orchard in 1944 received practically the same spray materials as in 1943. This was done in order to provide answers to specific questions asked by Indiana growers. The treatments used have been proven to be the best we know of at the present time. Each plot received a schedule which, if diligently and thoroughly applied and if fortified by good sanitation practices, bait trap data for timing sprays and a few extra sprays on years during which the codling moth is especially bad, will control the insect to the point where the wormy fruits will be held to 15 percent or less and will do so with a minimum of foliage injury. The tables following provide most of the information as to the number of sprays applied, the control resulting from each treatment during the first brood period and at harvest and the cost of each program with respect to the codling moth damage.

The figures are based on actual production records from blocks of 50 mature trees producing an average of 7.66 bushels per tree for plot one, 6.43 bushels for plot two, 6.36 bushels for plot three and 7.43 bushels per tree for plot four. In these plots in 1943 the per tree production averaged 15 bushels per tree. In 1943 the same trees were used for each treatment as in 1944 and each included Jonathan, Winesap, Stayman and Rome Beauty. Each treatment was replicated once, on all varieties.

Table 1 - - Spray Schedule and Infestation Counts - Elrod Orchard - - - 1944

Plot	Cover Sprays 1/	Materials 2/ (Amounts per 100 gallons)	Date of Sprays	Average Injury per 100 Fruits (all varieties): First Brood W	First Brood S	HARVEST W	HARVEST S	AFF.
I	1	5# MS, 3# LA	May 18					
	2-8	1 pt. BL 40, 8# MB x 110,	May 27					
		1 qt. MO	June 13					
	9	2# BL 155	June 19	5.3	17.3	52.0	47.0	54.7
			July 6					
			July 17					
			Aug. 2					
			Aug. 14					
			Aug. 25					
II	1	1 1/4# F, 3# LA	May 18					
	2	3# LA, 1# L, 1/2 gal. MO	May 27					
		1# $ZNSO_4$	~~June 14~~	4.2	13.1	141.6	291.4	85.6
	3-4	3#, 3# L, 1/2 gal. MO	June 14					
		1# $ZNSO_4$	July 6					
	5	3# LA, 1#, 1/2 gal. MO						
		1# $ZNSO_4$	July 27					
	6	2# BL 155, 2 qts. MO						
		1# MB	Aug. 12					
III	1	1 1/4# F, 3# LA	May 18					
	2	3# BL 155, 1/2 gal. MO	May 30					
	3-4	3# BL 155	June 12					
	5-9	2# BL 155 1/2 gal. MO	June 20					
	10-11	3# BL 155	June 28	7.3	13.9	52.8	66.8	62.1
			July 7					
			July 15					
			July 25					
			Aug. 2					
			Aug. 12					
			Aug. 25					
IV	1	1/4# F, 3# LA	May 18					
	2	3# LA, 6 2/3 oz S,	May 31					
		1/2 gal. MO	June 15	4.9	10.7	86.8	170.2	66.8
	3	4# LA, 1/2# S, 1/2 gal.						
		MO	June 23					
	4-6	5# WB, 1# 13 oz. S,	July 20					
		1/2 gal. MO, 1# ALSO	Aug. 3					

1/ Entire orchard received--Six sprays for apple scab applied between April 10 and May 17
2/ Wettable sulphur used in the calyx applications with 3# lead and 3# lime

MS - Micronized Sulphur
F - Fermate
LA - Lead Arsenate
MB - Mississippi Bentonite (x110)
MO - Mineral Oil (302 Gulf and Latis 15)
BL 155 - Black Leaf 155 (nicotine)

$ZNSO_4$ - Zinc Sulphate
L - Lime
S - Soap
WB - Wyoming Bentonite
ALSO - Aluminum Sulphate
N - BL 40

Costs In Producing Apples Using The Four Spray Schedules Studied at the Elrod Orchard in 1944

G. Edw. Marshall, Department of Entomology

Figures are based on actual production records of each treatment applied to a block of 50 mature trees, with an average price of $3.50 per bushel for U. S. No. 1's, $2.00 for those with two or more stings, and $1.00 for wormy fruit. Labor costs were charged at the prevailing wage and spray materials were charged at prices quoted for lots such as would be used for a 200-tree orchard.

Dec. 1, 1944 Purdue University Agricultural Experiment Station

Schedule used	Number sprays	Cost of Materials $	Cost of Labor $	Bu. apples per tree	Codling moth attack per 100 apples: Affected	Stings	Worms	Cost of codling moth damage $	Cost of codling moth damage Mat'ls and labor $	Value of crop without codling moth damage $	Net value $	Net per bushel $
Tank-Mix Nicotine bentonite	9	101.46	106.65	7.66	54.7	47.0	52.C	464.89	672.00	1340.50	668.50	1.74
Lead arsenate and oil with zinc sulphate and lime	6	47.17	71.10	6.43	85.6	141.6	291.4	496.82	615.09	1125.25	510.16	1.59
Black Leaf 155 at 7 to 10 day schedule	11	146.90	130.35	6.36	62.1	52.8	66.8	291.04	568.29	1113.00	544.71	1.82
Lead-oil-soap 3 applications, Floc. Bentonite 3 applications	6	45.04	71.10	7.43	66.8	86.8	170.2	417.93	534.07	1300.25	766.18	2.06

KANSAS

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Introduction

The tests of spray materials and combinations were again conducted at the Blair experiment orchard, Blair, Kansas, during the season of 1944. The only new spray material used was "Gesarol A 20 Spray" concentrate, a compound containing "DDT" (Dichloro-diphenyl-trichloroethane). Standard dosages of lead arsenate, lead arsenate plus zinc sulfate plus summer oil emulsion, as well as fixed nicotine ("Black Leaf 155") plus summer oil emulsion combinations were compared. The zinc sulfate was used as a safener, buffer, or corrective of lead arsenate. The "Top-off" spray innovation developed by G. E. Marshall of the Purdue Agricultural Experiment Station also was tested.

Methods and Procedure

Two-tree replicates of the Jonathan variety were used for each insecticide or combination to be tested. To obtain as near uniform conditions as possible for the test, the replicates were randomized throughout four rows of trees containing ten trees to the row. As a protection to the test plots, lead arsenate-zinc sulfate-summer oil spray applications were applied to all trees surrounding the replicates on the same day as the trees under test were sprayed. A calyx and eight cover sprays were applied. Two early sulfur sprays were applied to the plots for scab control. Summer oil emulsion was left out of the sprays used on the zinc sulfate-lead arsenate plots after the fifth cover spray. The "top-off" spray was applied as follows: These trees were sprayed in the regular manner, then, after the spray had dried, the top third of the trees again were sprayed. To prevent excessive fruit drop, two hormone spray applications of a naphthalene acetic acid were applied; the first application was made September 6 and 7, the second on September 13 and 14.

The purpose of the DDT test was to determine how this material would compare to lead arsenate as a control for codling moth, and whether the common red spider would be controlled when no oil was used in the spray mixture. The DDT and the lead arsenate plots were sprayed on the same dates and in the same manner.

Wormy, stung, and clean dropped apples per trees were recorded at intervals during the summer. Preharvest dropped apples to the number of 250 per tree were collected and recorded September 4 through 9. A harvest count of 250 picked fruits per tree was made September 21. Percentage of effectiveness in control of codling moth was computed on a seasonal plot summary basis.

Seasonal Conditions and Codling Moth Abundance

First Brood. The first recorded catch of adult codling moths during the season of 1944 was that of a single moth on May 18. By May 22, emergence was well under way. May 23 to June 3 was an interval of large catches. There were, however, no outstanding peak catches. The first worm entries were noted on May 29.

Unseasonably warm weather from May 18 to June 3 resulted in early egg-laying and a prompt hatch of eggs. Delays in spraying were caused by dashing rains which, combined with rapid growth of fruit, made protection by spraying difficult. Attempted worm entries were numerous during the interval of June 1 to 6. From June 9 to 26 there was a rather steady and straggling adult emergence. There was, however, continuous evidence of hatching eggs and attempted worm entries during this interval. From June 26 to July 10 there was very light adult codling moth emergence.

Second Brood. On July 10 the first second brood moths were noted in the emergence cage. As in former years, the emergence cage gave more reliable information as to the beginning of the second brood than did the bait traps. Emergence of second brood moths followed much the same pattern as that of first brood moths, being characterized by many highs and lows in terms of numbers of moths caught. There were, as with the first brood, no outstanding peak catches; only days of alternating high and low catches which closely followed weather conditions.

From July 10 to August 20, damage from second brood worms was steady and consistent throughout this interval. Due to heavy rains, codling moth activity was at a low point during the interval of August 20 to 27. Cool weather until September 6 accounted for further reduced codling moth activity.

Warmer weather following September 6 resulted in higher moth catches and a hatch of late worms started about September 15. Damage from this late hatch was somewhat retarded by unfavorable weather conditions.

Third Brood. As far as observations for this region could be made, there was no definite third brood. Late worms resulted from the delayed emergence of late second brood moths.

Seasonal Damage

Control was fair in most orchards receiving the required number of first-brood sprays. Some delay was caused in the timely application of the sprays, due to excessive rains in June. Emergence of first-brood occurred from May 18 to July 10. Worm damage of the first brood was steady and consistent from May 29 to July 10. Temperatures were never high enough during this interval to hinder codling moth development.

In orchards where first brood control was poor, severe worm damage resulted from second brood worms. A late hatch of second brood worms was in progress about September 15, but attempted entries were so few that they were largely overlooked on the grading table. Moths still were being caught September 15, when bait trap work was discontinued.

Materials and Dosages

The combinations of insecticides used in 1944 are indicated in Table I.

Table I. Insecticides and dosages used in control tests in pounds per 100 gallons of spray mixture.

Treatment: (Calyx spray, lead arsenate, 4 lb. except for "DDT" which had "DDT", 2 lb.)

1. Lead arsenate, 4 lb.

2. Lead arsenate, 4 lb. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. Oil left out after fifth cover spray.

3. Lead arsenate, 4 lb. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. through first 4 cover sprays (first brood); "Black Leaf 155", 2 lb. plus Superla oil, 2 qt. fifth through ninth cover sprays (second brood).

4. "Black Leaf 155" schedule of sprays.
First cover, lead arsenate, 4 lb.; second cover, lead arsenate, 3 lb. plus B. L. 155, 1 1/2 lb.; third cover, lead arsenate, 3 lb. plus B. L. 155, 2 lb. plus Superla oil, 2 qt.; fourth cover, B. L. 155, 2 lb. plus Superla oil, 2 qt.; fifth cover, B. L. 155, 2 lb. plus Superla oil, 2 qt.; (beginning of second brood) sixth through ninth cover, B. L. 155, 2 lb., plus Superla oil, 2 qt.

5. "DDT" ("Gesarol A20 Spray" Concentrate), 2 lb.

6. Lead arsenate "Top-off" spray.
Lead arsenate, 4 lb. plus zinc sulfate, 4 oz. plus Superla oil, 1 qt. Oil left out after fifth cover spray. Top third of trees sprayed immediately following the regular spray. (see treatment number 2).

7. Lead arsenate sprays plus trap band.
Lead arsenate, 4 lb. plus zinc sulfate, 4 oz. plus Superla oil, 1 qt. (same as number 2) "Gesarol SHN5" treated band applied to tree trunk during first brood development.

As in past years, information was gathered from two sets of codling moth bait traps. One set of 10 traps was located at the Blair experiment orchard, Blair, Kansas. The other set of 10 traps was at the Frank Lehman Orchard, Wathena, Kansas. Daily moth catches and 8 spray dates were sent to the Doniphan County Farm Bureau which in turn sent the information to growers. Spray dates for the season of 1944 were as follows: Calyx, May 25; first cover, May 30; second cover, June 6; third cover, June 15; fourth cover, June 26; fifth cover, July 12; sixth cover, July 24; seventh cover, August 7, and eighth cover August 24. An extra or a ninth cover spray was applied to the nicotine plots on July 7.

At harvest time samples of apples from all plots were stored from September 15 to November 8, then analyzed for arsenic residue. A sample of apples from the DDT plot was analyzed on December 29, 1944, for DDT residue.

Results

In recording the data from injured fruits, multiple stings or worms in a single fruit were not considered. When a fruit had both worms and stings present, it was recorded as "wormy".

The foliage on all trees of spray plots at the Blair experiment orchard appeared to be in good condition on August 7, except for the lead arsenate without safener plot where foliage injury was already apparent. On August 14, foliage injury was evident to a marked degree on the trees of all plots regardless of the material used for control. The lead arsenate-zinc sulfate plots had much better foliage on this date than any of the other plots under test. By August 14 the foliage on the trees of the DDT plots appeared to be slightly copper colored due to a medium heavy outbreak of red spider. Examination of leaves and trunks of the trees on August 16 revealed that the red spiders were already starting to hibernate. The foliage of the two trees sprayed with DDT showed more damage from red spider than did the trees of any of the other plots under test. Whether this tendency of the foliage to develop this marginal leaf burn was due to fungus or chemical injury to the leaves is not known for sure--perhaps it was a combination of both. The condition appeared following heavy rains and humid weather conditions.

The value of zinc sulfate as a safener for lead arsenate was again apparent. The foliage of the trees on this plot was still in excellent condition when compared with that on the other plots at harvest time. Only 25 percent of the foliage on the trees of lead

arsenate alone plot remained on the trees at harvest time, September 21. Two applications of a hormone spray of naphthalene acetic acid failed to hold the fruit on these two trees that had such heavy foliage loss. Good success in holding the fruit on the trees of the other plots in the test was achieved with two hormone sprays.

The preharvest drop began September 1 to 3. There was a marked tendency for the fruit on the lead arsenate alone and the DDT plots to drop their fruit first. On September 4, 250 fruits were scored from each of the trees in these two plots. Two hormone sprays were applied, one September 7, the other September 13 and 14. The tendency of the fruit to drop was halted until September 21, when the crop was picked.

Data of the various insecticide tests for the control of codling moth in the Blair experiment orchard at Blair, Kansas, are recorded in Tables II and III.

Table II. Percentages of wormy and stung apples during various periods and the entire season, and residue analyses.

Treatment	Apples dropped to August 31			Preharvest drops September 4 to 9			Harvest counts		Summary (entire season)				Residue (grains As_2O_3 per pound) 4/	
Number	Total per Plot	Per-cent Wormy	Per-cent Stung	Total per Plot	Per-cent Wormy	Per-cent Stung	Per-cent Wormy	Per cent Stung	Total per Plot	Per-cent Wormy	Per-cent Stung	Per-cent Clean	Unwashed	Washed
1.	671	10.0	7.9	500	10.4	20.6	2.4	39.2	1671	7.8	21.1	71.1	.12	.03
2.	283	2.8	8.5	345	2.3	16.8	0.8	26.0	1028	1.9	20.6	77.5	.165	.036
3.	713	8.8	3.3	500	9.4	3.4	1.2	7.4	1713	6.8	4.5	88.7	.11	.04
4.	451	9.1	2.9	391	4.9	6.1	1.2	7.2	1342	4.9	5.5	89.6	.045	.0057
5.	883	23.3	7.1	510	34.5	10.6	20.4	20.6	1843	25.6	11.7	62.7	trace	trace
6.	395	4.8	5.6	383	2.6	12.8	0.2	14.2	1278	2.4	11.1	86.5	.2	.042
7.	391	5.9	6.9	308	8.4	13.0	2.4	25.4	1199	5.1	16.2	78.7	.125	.04
													Residue (grains DDT per pound) 4/ 5/	
5.	---	---	---	---	---	---	---	---	----	---	---	---	.001	

4/ Residue analyses were made by Dr. B. L. Smits, Department of Chemistry, Kansas State College.

5/ Residue analysis of DDT by the Gunther hydrolysis method.

Table III. Numbers and percentage of codling moth larvae cought in lethal or "automatic" trap bands on well sprayed and poorly sprayed trees, October 16.

Type of Band	Plot No.	Number of worms Live	Number of worms Dead	Total No. worms per tree	Number of pupae cases	Percent of worms Live	Percent of worms Dead
Beta Napthol	A Poorly sprayed	68	156	224	1	30.36	69.64
Gesarol SHN5	B Poorly sprayed	92	61	153	7	60.13	39.87
Gesarol SHN5	7	4	0	4	1	100.00	0

Plot 7 is one of the lead arsenate-zinc sulfate-summer oil emulsion combination treatments of the spray schedule of tests. Some live larvae under the bands inspected were undoubtedly injured by chemicals in the bands and would have died later. For sake of comparison, any worm capable of movement was counted alive.

Discussion

"Gesarol A20 Spray" as with many other substitutes for lead arsenate tested in previous years, indicated good worm control through the first brood. After second brood worm injury began, inferior worm control was apparent by August 7. By August 14, this inferiority in control was quite pronounced and grew progressively evident until harvest time. This plot produced only 62.7 percent sound fruit for the season. This was inferior to the zinc sulfate-lead arsenate plot by 14.8 percent. In terms of sound fruit produced, this plot made the poorest showing of any of the seven plots under test. A representative of the Geigy Company stated that "Gesarol A20 Spray" has too much of a wetting agent incorporated, "Gesarol AK20 Spray" is an improved horticultural spray combination and does not have as much run-off as "Gesarol A20 Spray".

The zinc sulfate-lead arsenate-summer oil plot in terms of unblemished fruit ranked third of all the plots under test. By far the greatest injury to fruit in this plot consisted of small well healed stings that would affect very little the grade of the fruit. Foliage condition, as has been noted before, was superior to all other plots.

Severe foliage loss was sustained by the trees in the lead arsenate without safener plot. In terms of percentage of sound fruit, this plot was next to the poorest of all the plots.

"Top-off" sprays showed a gain in effective control of 9.1 percent above the lead arsenate-zinc sulfate-oil test which was achieved by respraying the top third of the trees immediately after the regular spray application had dried.

The use of summer oil emulsion in combination with lead arsenate sprays during rainy seasons is justified by results of this test. Data in Table II indicate that the use of oil in some of the cover sprays gives more effective control. The lead arsenate alone plot shows a decrease of 7 percent in control when compared with the lead arsenate-zinc sulfate-summer oil combination spray.

As would be expected under the diverse spray control programs, there were fewer larvae caught in trap bands on the trees which had good dosage, coverage and timely spray applications than on the trees given poor spraying care (Table III). Plot 7 of the spray control tests had an extremely low number of larvae which entered the bands. In an orchard which is given satisfactory spraying for codling moth control, there are comparatively few larvae escaping to pupate on the tree trunk. "Gesarol SHN5" treated trap bands killed a little more than one-third of all the worms entering the bands; whereas, the beta napthol treated bands killed slightly more than two-thirds of the worms under similar conditions.

Apple samples harvested September 14 were stored from September 15 until November 8 before arsenic analysis was made. It is known that stored apples form a waxy coating during storage. This waxy formation inhibits arsenic residue analysis.

Arsenic tolerance of 0.025 grain of arsenic per pound of apples is allowed by the Federal Security Agency. The use of oil in cover sprays following the fifth cover spray and apple changes in storage, increase the difficulty of removing the arsenic from the harvested apples by the standard acid wash (Table II).

The determination of the residue of DDT was made late in December by the hydrolysis method of Gunther (Table II.)

Summary

The trees in the plot sprayed with "Black Leaf 155" and summer oil emulsion under the fixed spray schedule, for the second season, gave the most effective control, 89.6 percent as expressed as clean fruit per plot for the season. This year this plot had the fifth highest percentage of wormy apples of the 7 insecticide combinations used. One more cover spray was applied to this nicotine plot than was to the other plots or a total of 9 cover sprays for the season.

The trees in the plot sprayed with lead arsenate-zinc-sulfate-summer oil emulsion to control the first brood larvae; and with "Black Leaf 155"-summer oil emulsion combination for the control of the second brood larvae (biological spray timing), was second in effective control of 88.7 percent clean fruit. This plot had the third highest percent of wormy apples of all the insecticide combinations tested.

The trees in the plot sprayed according to the "Top-off" schedule, respraying the top third of the trees immediately was third in effective control or had 86.5 percent clean fruit. This plot had the sixth highest percentage of wormy apples of all test plots.

The trees in the plot sprayed with lead arsenate-zinc sulfate-summer oil emulsion, with the oil left out after the fifth cover spray, plots 2 and 7 were fourth and fifth, or 77.5 and 78.7 percent respectively in the production of clean fruit. Both of these plots were relatively low in the percentage of wormy apples of all plots.

The trees in the lead arsenate without safener plot had next to the lowest, or 71.7 percent clean fruit. This plot had next to the highest percent of wormy apples of all plots.

The trees in the plot sprayed with "Gesarol A20 Spray", DDT, and in which the calyx spray was of the same material, had the lowest effective control of 62.7 percent clean apples. This plot also had the highest percentage of wormy apples of all plots.

During late July and through August the common red spider population on the trees in the DDT plot built up to medium heavy outbreak numbers. The foliage of these trees was more heavily damaged by this pest than on the trees in the other plots where oil was used in the spray mixture.

Zinc sulfate is an effective safener for lead arsenate and the foliage of the trees in the plots where this chemical was used in excellent condition when compared with that of the other plots at harvest time. At harvest time there was only 25 percent of the foliage remaining on the trees of the lead arsenate alone plot.

Two applications of naphthalene acetic acid, a hormone spray, were applied to the trees to prevent premature dropping of apples. The fruit on the trees of the lead arsenate alone and DDT plots dropped early, due to the chemical and red spider injury of foliage of the trees during the latter part of the season. The fruit of the trees of the other plots to which the hormone spray was applied was retained until harvest on September 21.

In general, the trees in the plots in which lead arsenate-zinc sulfate-summer oil emulsion combination was used had less wormy and more stung apples than those in the fixed nicotine plots.

When summer oil emulsion is used in combination with lead arsenate during seasons of much rain, there is better codling moth control than without oil.

When an orchard is given a suitable spraying for codling moth control, only a comparatively few larvae escape to spin up on tree trunks. "Gesarol SHN5" treated trap bands killed a little more than one-third of all the worms entering the bands; whereas, the beta napthol treated bands killed slightly more than two-thirds of the worms under similar conditions.

All samples of unwashed, stored, harvest apples which had been sprayed with lead arsenate, when analyzed for arsenical residue, had more than the tolerance of 0.025 grain of arsenic per pound of fruit. The acid wash did not reduce all of the residues to below tolerance. The surface wax formation of stored apples inhibited the usual routine residue removal.

The sample of harvest apples which had been sprayed with DDT, when analyzed for this chemical, had a residue of .001 grain of DDT per pound of apples. The analysis was by the Gunther hydrolysis method. The residue of .001 grain of DDT per pound of apples at the end of the production season is too low for good control.

KENTUCKY

W. A. Price and P. O. Ritcher, Kentucky Agricultural Experiment Station, Lexington.

There was a large carry-over of codling worms from 1943 and low winter mortality. At Paducah, moth emergence began April 26. This was only a few days after the application of the calyx spray. Moth emergence was heavy from May 9 to May 21 and continued into early June. Emergence of first generation moths began the third week in June in western Kentucky and trap catches later in the month were heavier than at the peak of spring brood emergence. Prolonged hot, dry weather in July and August was favorable for codling moth establishment and reduced the effectiveness of lead arsenate spray deposits. Heavy moth emergence continued during July, August and early September and there was continuous hatch of new worms. By harvest time many crops were very wormy and some growers lost their entire crop.

At Lexington, moth emergence began May 12 and continued through the second week in June. Emergence was more bunched than usual with the peak of emergence occurring from May 18 to May 22. Emergence of first generation moths was unusually heavy during the latter part of July and first part of August. Some commercial crops were unusually wormy in spite of repeated spraying with lead arsenate, weak-bordeaux combinations.

MARYLAND

Castillo Graham, University of Maryland, Department of Entomology, College Park.

CODLING MOTH CONTROL BY DDT SPRAYS AT CORDOVA, MARYLAND IN 1944

A block of trees in an apple orchard located at Cordova, Maryland was selected for tests against codling moth with DDT and compared with the standard spray of lead arsenate, oil and nicotine. The DDT used was Gesarol AK 20 spray which contained 20 percent GNB - A - DDT supplied by the Geigy Company, Inc., of New York. The amount of material listed in the sprays represents pounds of actual DDT. The block consisted of five acres of ten-year old trees of Stayman Winesap, Red Starking and Grimes Golden, which were partly surrounded by a block of old trees that for the past several years have had from 50 to 80 percent of the fruit injured by codling moth, even though a heavy spray program consisting of lead arsenate, nicotine and oil had been practiced. The block selected for the tests had a 40 percent crop in 1943 which showed close to 100 percent of the fruit injured by codling moth with about 80 percent wormy. In that year the entire orchard received seven lead arsenate sprays, three of which had one pint of nicotine sulfate and one gallon of summer oil added per 100 gallons.

Eight rows were selected for the experiment each of which contained 12 trees, six Stayman Winesap, three Red Starking and three Grimes Golden. Records were taken on all the apples including drops from one tree of each variety from each row: 34,321 Stayman Winesap, 18,690 Red Starking and 38,770 Grimes Golden, a total of 91,781. All sprays were applied by the grower with a machine that gave about 500 pounds pressure; about twelve gallons of spray were applied per tree per application. Lead arsenate was used at the rate of three pounds per 100 gallons of spray unless otherwise stated.

Rows 1 and 8 were given the standard treatment consisting of seven lead arsenate sprays with one pint of nicotine sulfate and one gallon of summer oil added to the 2nd, 3rd, 6th and 7th covers. Row 1 was located on one side of the DDT block and separated from it by one buffer row with the standard treatment. Row 8 was on the opposite side of the DDT plot and also separated from it by a buffer row. Row 2 received lead arsenate in the first five sprays with 1 pint of Black Leaf 40 and one gallon of summer oil added to the 2nd and 3rd cover sprays.

DDT one pound plus three ounces of sodium lauryl sulfate per 100 gallons was used in the 6th and 7th cover sprays. Row 3 received lead arsenate in the petal fall spray and DDT 1 1/2 pounds plus 3 oz. of sodium lauryl sulfate per 100 gallons in six sprays. Row 4 received lead arsenate in the petal fall spray and 1 pound of DDT plus 3 ounces of sodium lauryl sulfate per 100 gallons in six sprays. Row 5 received 1 pound of DDT plus 3 ounces of sodium lauryl sulfate per 100 gallons in the petal fall and in five cover sprays. (Through a misunderstanding the 1st cover was omitted.) Row 6 received lead arsenate in the petal fall and 1/2 pound DDT plus 3 ounces of sodium lauryl sulfate per 100 gallons in six sprays. Row 7 received lead arsenate in petal fall and 1/2 pound DDT plus 1 pound lead arsenate plus 3 ounces of sodium lauryl sulfate per 100 gallons in six sprays. The last sprays on all rows were applied July 25. The materials used, the average percentage of worms, stings and clean fruit for all varieties and DDT in grains per pound of fruit on the Grimes Golden are shown in Table 1.

Table I. A comparison of codling moth control with different strengths of DDT and with other insecticides

Row No.	Material Used	Number Apples Examined	Worms	Stings	Worms and Stings	Clean Fruit	DDT 1/ gr/lb
			%	%	%	%	
1 and 8	3 lb. lead in 7 sprays plus nicotine & oil in 2, 3, 6-7 covers.	22,187	24.6	13.1	37.7	62.3	
2	3 lb. lead in first five sprays plus oil and nicotine in 2 and 3 covers. 1 lb. DDT in 6th and 7th covers.	11,968	17.3	6.5	23.8	76.2	.030
3	3 lb. lead in petal fall, 1 1/2 lb. of DDT in other six sprays.	10,572	14.3	3.1	17.4	82.6	.060
4	3 lb. lead in petal fall, 1 lb. DDT in other six sprays.	12,626	24.2	3.9	28.1	71.9	.032
5	1 lb. DDT in petal fall (skipped first cover spray). 1 lb. DDT starting with 2nd cover for 5 sprays.	12,694	24.1	4.6	28.7	71.3	.035
6	3 lb. lead in petal fall, 1/2 lb. DDT in other 6 sprays.	9,663	41.0	5.1	46.2	53.8	.022
7	3 lb. lead in petal fall, 1/2 lb. DDT plus 1 lb. lead in other six sprays.	12,000	27.7	4.3	32.0	68.0	.021

1/ DDT analysis by the insecticide division of the Bureau of Entomology and Plant Quarantine.

All trees in the orchard where the tests were run had a full crop of apples. Past experience with standard sprays has shown that the lighter the crop the greater the percentage of codling moth injury. This generalization appears questionable in light of the results obtained with DDT on Red Starking in which the number of apples per tree was only approximately one-half the other varieties, the percentage of injury was nearly the same when 1 pound or more of DDT was used. The number of apples per tree, percentage of worms, stings and clean fruit for each variety in each test are shown in Table 2.

Table II. A comparison of insecticide treatments according to size of crops.

Row No.	Material Used	Variety	Number of Apples	% Worms	% Stings	% Clean Fruit
1 and 8	Lead in 7 sprays plus nicotine and oil in 2,3,6-7 covers.	Grimes	6,287	26.3	14.2	59.5
		Stayman	3,771	12.6	8.7	77.1
		Red Starking	2,305	34.8	16.0	49.2
2	3 lb. lead in 1st five sprays plus oil and nicotine in 2 and 3 covers. 1 lb. DDT in 6 and 7 covers.	Grimes	6,092	14.1	7.8	80.3
		Stayman	4,176	13.5	4.5	82.1
		Red Starking	1,700	28.2	11.4	60.4
3	3 lb. lead in petal fall, 1 1/2 lb. DDT in other six sprays.	Grimes	4,282	12.8	4.3	82.9
		Stayman	2,415	14.4	1.8	83.8
		Red Starking	1,875	15.9	4.4	79.7
4	3 lb. lead in petal fall, 1 lb. DDT in other six sprays.	Grimes	5,138	18.6	4.7	76.7
		Stayman	4,774	28.2	3.5	68.3
		Red Starking	2,714	22.0	3.7	74.3
5	1 lb. DDT in petal fall (skipped first cover spray). 1 lb. DDT starting 2 cover for 5 sprays.	Grimes	4,361	29.1	3.8	66.1
		Stayman	5,629	18.4	3.8	77.8
		Red Starking	2,704	30.7	6.9	62.4
6	3 lb. lead in petal fall. 1/2 lb. DDT in other 6 sprays.	Grimes	4,219	42.8	6.6	50.6
		Stayman	3,691	34.3	4.2	61.4
		Red Starking	1,753	52.8	5.3	41.9
7	3 lb. lead in petal fall. 1/2 lb. DDT plus 1 lb. lead in other 6 sprays.	Grimes	4,901	18.8	4.9	76.3
		Stayman	3,996	23.1	4.5	72.4
		Red Starking	3,183	43.7	3.3	53.0

An analysis of the percentage of clean fruit of each variety shown in Table 2 indicates that when DDT was used at the rate of one pound or more per 100 gallons in six sprays the percentage of clean fruit remained approximately the same on all three varieties. In those rows where DDT was used at less than one pound in five sprays, or one pound in two sprays and in the check rows, the clean fruit on the Red Starking was much less than on either of the other varieties.

Discussion: When DDT was used at one pound or more in five sprays codling moth injury was held to a minimum until after August 10. The other combinations varied in effectiveness in holding the first brood moths, with one-half pound DDT being the least effective. In all cases the greater part of the injury occurred after August 10. It appears reasonable that the infestation on all rows could have been greatly reduced by the addition of two applications of spray, one on August 10 and the last approximately August 25.

Any combinations in which DDT was used proved more effective in reducing stings than the standard spray, but failed to show the same efficiency in reducing worms.

No injury was observed to the trees from any of the combinations used. No injury was noticeable on the Grimes or Stayman at harvest, but the Red Starking showed a russeting that was believed to be heaviest on the row sprayed with 1 1/2 pounds of DDT.

About the first of August, a severe infestation of European red mite developed on all the rows sprayed with DDT. The remainder of the orchard received four applications of oil and no red mite infestation developed.

Conclusion: From these tests it appears that DDT in all strengths and combinations used in these tests except the one-half pound dosage, gave as good as or better control of codling moth than the standard sprays used as checks.

The data in Table 2 indicate that where DDT is used at the strength of one pound or more per 100 gallons of spray the percentage of clean fruit will be approximately the same regardless of the size of the crop. This is not true in case of the standard schedules.

MASSACHUSETTS

A. I. Bourne, Massachusetts Agricultural Experiment Station, Amherst.

The tests in 1944 included studies of the relative effectiveness in insect control of modifications of the Standard Spray Schedule toward more accurate timing of applications on insect activity: the value of non-arsenical insecticides to supplement the standard schedule and a study of one form of DDT (Gesarol A-20) as an orchard spray material.

All materials were used in combination with wettable sulfur to determine their compatibility and effectiveness in disease control.

The early part of the season was somewhat ahead of normal and up to and through the Calyx application the sprays, since they are based on bud development, were correspondingly advanced. It was necessary to insert a special curculio application between the 1st and 2nd cover sprays to bring the schedule back into line. Consequently the 2nd cover and following applications were in close correspondence with similar sprays in normal years.

Emphasis was laid on the emergency Codling Moth Spray interposed between the 2nd and 3rd Covers which was intended to fill the gap existing between the 2nd Cover about mid-June and the 3rd Cover in early July. Normally this space of nearly a month is vacant and experience had indicated that this gap allows much Codling Moth activity to take place.

Special interest was shown in the study of DDT in the control of orchard pests.

The season was not conducive to spray injury provided reasonable care was taken in selecting dates for application. None of the applications were made under extreme conditions of either temperature or humidity, and no trace of spray injury or fruit russeting was noted.

Treatments and Results.

(1) In the sprayed plots codling moth damage was almost entirely confined to late season "stings." The results following the different schedules were as follows:

Treatment	Percentage of Codling Moth Damage
Standard Schedule 1/	15.6
Standard + 1 application Fixed Nicotine replacing lead in 4th Cover	13.6
Standard Schedule with Fixed Nicotine in 4th Cover and a mid-August spray	5.2
Standard Schedule with emergency spray between 2nd and 3rd Covers	1.4
Gesarol (DDT A-20), 2 lb. to 100 gallons	10.2
Check	57.9

1/ Standard schedule for codling moth (Materials per 100 gallons).

1/ (Continued)

Calyx - Lead arsenate, 4 lb.; lime, 8 lb.

First Cover (5 days after petal-fall + time until maximum temperature reaches 75 and promises to reach it on 2 successive days) - Lead arsenate, 4 lb.; lime, 8 lb.; fish or raw linseed oil, 1 pt.

Second Cover (7-10 days after 1st cover) - Lead arsenate, 4 lb.; lime, 8 lb., or 3:1 sulfur-lead arsenate dust.

Third Cover (about July 10) - Lead arsenate, 3 lb.; lime, 6 lb. or 85:15 sulfur-lead arsenate dust.

Fourth Cover (2-3 weeks after 3rd cover) - Lead arsenate, 2 lb.; lime 4 lb. or 85:15 sulfur-lead arsenate dust.

(2) In one block in which magnesium sulfate (Epsom salts) was applied to correct magnesium deficiency, samples of fruit from both treated and untreated areas of the same block were checked at the request of the manufacturer for relative amounts of insect and disease injury. Codling moth injury in this block was as follows:

Standard schedule (no magnesium)	2.1% codling moth injury
Standard schedule (+ magnesium)	3.8% codling moth injury.

(3) In one block, in cooperation with a leading insecticide company, tests were made of the comparative value of a specially prepared heavy deposit-building dust. The entire block received the Standard Schedule through the calyx application. A portion of the block was subsequently divided into two sections, one receiving the heavy deposit dust and the other the regular type dust for the remainder of the season. The comparative results were as follows:

Standard Spray Schedule	6.84%	codling moth injury
Regular type dust	3.83%	codling moth injury
Heavy deposit dust	3%	codling moth injury

MISSOURI

Lee Jenkins, Missouri Agricultural Experiment Station, Columbia.

I. Seasonal conditions and status of codling moth infestations during 1944.

The overwintering codling moth populations in the state, as a whole, were a little below the average in the spring of 1944. The populations in the University orchard, where most of the experimental work was done, were fairly high. The cool weather during early spring prevented the first moths from appearing till about ten days later than normal. First brood control was reasonably good. Weather conditions ideal for codling moth development during the second and third broods allowed worms to cause severe damage to the apple crop over most of the state. Northwest Missouri had more rainy weather than most of the remainder of the state, and the cleanest fruit was grown in that area.

II. Studies on codling moth biology or behavior.

Studies are being made to determine the influence of variety and date of ripening of apples on the codling moth populations that carry-over winter on the tree trunks. Bait trap records were kept in five areas of the state.

III. Results of control experiments.

Experimental set-up. The major part of the experimental work in 1944 was carried on in the University Orchards, near Columbia, in cooperation with H. G. Swartwout of the Horticultural Department. Jonathan, Ben Davis, York, Winesap, and King David varieties were used in the test. Due to a light crop, it was necessary to use some Jonathan, Winesap, and King David trees that were not too uniform. It was also necessary to use blocks of trees in a number of different areas in the orchard with varying infestations. The Yorks and Ben Davis were fairly uniform.

Injury to foliage and fruit. Lead arsenate used all season without a corrective severely injured the foliage of Jonathan and Ben Davis. Arsenate of iron, known as scorodite, caused severe foliage injury to York when used at the rate of three pounds to 100 gallons. Nicosol at 3/4 percent, starting in the third cover, caused considerable of the characteristic oil spotting on the fruit. Black Leaf 155 and oil and Fermate used all season caused a sooty deposit to form on the fruit and foliage and caused the Yorks and Ben Davis to crack badly. DDT alone, or with oil, did not cause any injury to the fruit or foliage.

A. Control by insecticides.

The following arsenical materials were used (dosages are for 100 gallons): (1) Lead arsenate alone, (2) lead arsenate and Fermate, (3) lead arsenate and 1-1-100 zinc lime, (4) lead arsenate in first two covers followed by Black Leaf 155, (5) Black Leaf 155 without oil, (6) Black Leaf 155 with 1 quart of oil and Black Leaf 155 with 2 quarts of oil, (7) Nicosol 3/4 percent plus 1 pound bentonite starting in third cover, (8) Kolofix, 3 pounds plus 1 pint nicotine sulfate, starting in the fifth cover, (9) tank-mix nicotine bentonite, using 4 pounds Mississippi bentonite, 1/2 gallon of oil, and 1 pint of nicotine sulfate, starting with fifth cover, (10) 2 pounds of 20 percent DDT (Gesarol A20 spray), (11) 4 pounds of 20 percent DDT (Gesarol A20 spray), and (12) 1 quart of SH 20 Gesarol.

All plats received nine cover sprays, except the nicotine which received one additional spray. The last spray for all plats, except the nicotine, was applied on August 23. The last nicotine spray was made on September 5. Lead arsenate was used at the rate of 3 pounds per 100 gallons in all but the second and third covers, which had 4 pounds each. Lead arsenate was used preceding all spray programs, except the nicotines which started in the fifth cover. In these plats, Black Leaf 155, 2 pounds, and summer oil, 1/2 gallon, was used in the fourth cover, preceded by the regular lead arsenate program in the first, second and third covers.

The results are given in the following table:

On King David

Treatment	No. Trees	% Wormy	% Stung	% Clean
DDT (Gesarol A 20 Spray) 4 lb. to 100, beginning in 2nd cover	5	61.5	20.2	18.3
Gesarol A 20, 2 lb. to 100, beginning in 2nd cover	5	72.1	13.2	14.6
Gesarol SH 20, 1 qt. to 100 gallons	5	47.8	21.7	30.4
Lead Arsenate and Zinc Lime	5	53.7	25.9	20.2
Lead Arsenate alone	1	42.8	34.2	22.9

On York (beginning with 3rd cover)

Treatment	No. Trees	% Wormy	% Stung	% Clean
Gesarol A 20, 2 lb. to 100	2	47.8	29.5	22.5
Gesarol A 20, 4 lb. to 100	2	26.0	31.2	42.6
Gesarol A 20, 2 lb. to 100, plus 4 lb. Mike Sulfur	1	42.3	30.0	27.6
Gesarol SH 20, 1 qt. to 100 gallons	2	44.5	29.5	24.8
Arsenate of iron, known as scorodite, 3 lb. per 100 gallons	2	69.2	12.9	17.8
On Jonathan, Block No. 1				
Nicosol 3/4% plus 1 lb. bentonite, starting in third cover	3	87.4	2.3	10.1
Kolofix, 3 lb., plus 1 pt. nicotine sulfate to 100 gallons, starting in fifth cover	3	82.9	7.6	9.3
Tank-mix Bentonite, 4 lb. Mississippi bentonite, 1 pt. nicotine sulfate, 2 qt. summer oil to 100 gallons, starting in fifth cover	3	64.9	10.4	24.6
Lead Arsenate plus 1-1-100 Zinc Lime	1	86.9	6.9	6.1
On Jonathan, Block No. 2				
Lead Arsenate alone	1	49.1	21.7	29.0
Lead Arsenate plus 1-1-100 Zinc Lime	1	35.7	31.7	32.5
Black Leaf 155, 3 lb. to 100 gallons	1	75.0	5.8	19.1
Black Leaf 155, 2 lb. plus 1 qt. summer oil	1	56.4	13.6	29.8
Black Leaf 155, 2 lb. plus 2 qt. summer oil	1	34.0	7.5	58.4

On York

Treatment	No. Trees	% Wormy	% Stung	% Clean
Black Leaf 155, 2 lb., Summer oil, 2 qt. to 100 gallons	1 End Tree	38.2	19.7	42.0
Black Leaf 155, 2 lb., Summer oil, 1 qt. to 100 gallons	1	27.1	20.2	52.6
Black Leaf 155, 3 lb. to 100 gallons	1	60.6	20.1	19.3
Black Leaf 155, 3 lb., Fermate, 1 lb. to 100 gallons	1	45.7	28.3	25.9
Black Leaf 155, 3 lb., Fermate, 1 lb. to 100 gallons	1 End Tree	69.4	23.1	11.5
Lead Arsenate, plus 1-1-100 Zinc Lime to 100 gallons	1	35.8	42.9	21.1
Lead Arsenate alone	1	18.9	47.2	33.9
Lead Arsenate plus Fermate, 1 lb. to 100 gallons	1	44.3	42.4	13.2

On Ben Davis

Treatment	No. Trees	% Wormy	% Stung	% Clean
Lead Arsenate alone	1	27.9	35.2	36.9
Lead Arsenate plus 1-1-100 Zinc Lime	1	33.1	34.7	32.1
Lead Arsenate plus Fermate, 1 lb.	1	59.4	23.7	16.9
Lead Arsenate plus Fermate, 1 1/2 lb.	1	58.0	34.0	8.0
Black Leaf 155, 2 lb., Summer oil, 1 qt. to 100 gallons.	1	24.9	14.4	60.6
Black Leaf 155, 2 lb., Summer oil, 2 qt. to 100 gallons	1	24.6	12.2	63.1
Black Leaf 155, 3 lb. to 100 gallons	1	46.2	18.0	35.8

On Winesap

Treatment	No. Trees	% Wormy	% Stung	% Clean
Lead Arsenate	2	36.7	48.1	15.1
Lead Arsenate plus 1 1/2 lb. Fermate all season	2	62.8	33.4	3.7

Dormant tree trunk spray for controlling overwintering codling moth larvae.

This method of control was tested in March, 1944, and the following materials were used per 100 gallons of spray:

Stove oil (32 viscosity)	16 2/3 gallons
Dinitro-ortho-cresol	3 pounds
Ethylene glycol monobutyl ether	1 1/2 gallons
Ferric chloride	1/8 ounce
Dreft	6 ounces
Trichloroethylene	1 1/2 gallons

Three different treatments were compared. The dinotro-ortho-cresol was dissolved in acetone for all applications made at Columbia.

1. One treatment in which the special penetrant was used and the oil and DNOC were added separately.

2. One treatment with the penetrant omitted and the oil and DNOC added separately.

3. One treatment with the penetrant, in which the oil and the DNOC were mixed together before adding to the spray tank.

Results:

In Numbers 1 and 2, the DNOC formed a precipitate which settled to the bottom, and the kill was about 20 percent.

In Number 3, the materials remained mixed well and gave 100 percent kill of 17 larvae found on five Minkler trees. Check counts showed 12 larvae alive and none dead.

Mr. Harry Guengerich, at the Unity Farm, Lees Summit, Missouri, used the same formula as was used in Number 3 above, without the ferric chloride, applied to about 30 trees. He obtained over 80 percent kill.

In November, 1944, Mr. Guengerich used the following formula to kill codling moth larvae on tree trunks:

8 pounds of 40% DNOC manufactured by Niagara Chemical Company
15 gallons of stove oil
1/2 pint of B-1956

The DNOC in this formula was readily soluble in oil and did not require a special solvent for mixing. Additional agitation in the spray tank was required to keep the material mixed sufficiently.

Ten days after application, counts on four trees showed 20 larvae dead and 2 alive. Those alive were on a small scaffold branch that was not well sprayed.

Observations on other insects.

All of the DDT (Gesarol) sprays mentioned gave good control of leafhoppers on apple.

Gesarol A 20 Spray, at 4 pounds per 100 gallons, did not control San Jose Scale on the fruit.

NEW JERSEY

B. F. Driggers, New Jersey Agricultural Experiment Station, New Brunswick.

I. Seasonal Conditions and Status of Codling Moth Infestations During 1944.

There was a rather heavy carry-over of worms from the 1943 season, which was hot and dry during July, August and September when second and third brood worms were spinning winter cocoons. The heavy carry-over of worms was partly offset by about normal rainfall and temperature during the last half of May and the month of June when the first brood of worms was hatching. During July, August and the first half of September above normal temperatures and below normal rainfall was experienced over the state as a whole (the weather bureau reported the July-August period the hottest and driest period on record for the state). The weather, therefore, was quite favorable to codling moth during the period second and third brood worms were active. The season as a whole can be recorded as one in which codling moth was quite difficult to control and the insect caused extensive damage in many orchards.

II. Studies on Codling Moth Biology or Behavior.

No work done except maintaining bait pans and emergence cages for the purpose of timing moth emergence and worm activity.

III. Results of Control Experiments.

A. Control by Insecticides.

Field experiments aimed at improving the control of codling moth were carried on in two orchards in southern New Jersey, one at Shiloh and one at Glassboro, and one in central New Jersey in the College Farm orchard at New Brunswick. In all of the experiments DDT was tested in comparison with the standard lead arsenate or nicotine schedules.

Experiments at Shiloh. Two blocks of early ripening varieties, Yellow Transparent and Williams Early Red, in the orchard of Gorson and McCormick at Shiloh were used to compare DDT with lead arsenate as a control for codling moth and Japanese beetle. These experiments were carried out in cooperation with Dr. W. E. Fleming of the Japanese Beetle Laboratory of the Federal Bureau of Entomology and Plant Quarantine. Dr. Fleming supervised the preparation and application of the DDT, using the equipment (portable) and spray crew of the orchard owners. The writer made the codling moth counts at the end of first brood worm attack just before the fruit was harvested.

The DDT used in the two blocks of apples at Shiloh was of the following composition:

DDT micronized with an equal weight of Pyrophyllite	2 lb.
Glue solution (1 pound of fish glue per gallon water)	1 pt.
Orthol-K emulsion	2 pt.
Water	100 gal.

The source of the DDT was the Geigy Company of New York.

Both the Yellow Transparent and Williams Red blocks of apples were sprayed with lead arsenate at the petal fall and first and second cover sprays during May. On May 31st, at the time the third cover spray was due, part of the Yellow Transparent block (about 12 rows) and part of the Williams Red block (4 rows) were sprayed with the DDT mixture. The remainder of each block was sprayed on the same date with lead arsenate (2 pounds to 100 gallons) and summer oil emulsion (0.75% oil). Following this third cover spray the entire block of Yellow Transparent and Williams Red (including the DDT plots) were sprayed twice in June with oil-nicotine. This gave 5 cover sprays of lead arsenate alone or with oil or oil plus nicotine against first brood in which DDT was substituted for lead arsenate in one cover spray--the third--for lead arsenate-oil.

Codling moth counts were made in the DDT and standard sprayed plots in the Yellow Transparent block on July 6 and in the Williams Red block on July 21st. In making these counts ten trees in each plot were selected which carried a full crop of fruit. One hundred apples were examined on each tree. A stepladder was used and the apples were examined at random from the ground and as high as one could reach from the ladder. In addition to the tree fruit counts, the writer picked up and examined all the dropped apples from under each of five trees in the DDT plot and each of five trees in the standard plot in the Yellow Transparent block of trees. The data obtained are set forth in Table I.

Table I. Percentage of stung and wormy apples on DDT and standard sprayed plots.

Treatment	Number Examined		Percentage Apples	
	Trees	Apples	Stung	Wormy
	Yellow Transparent (on tree)			
DDT 1/	10	1000	1.4	0.1
Standard 2/	10	1000	4.1	1.0
	Yellow Transparent (drops)			
DDT	5	535	2.4	2.8
Standard	5	648	14.8	15.7
	Williams Early Red (on tree)			
DDT	10	1000	1.6	0.0
Standard	10	1000	3.9	0.4

1/ Standard treatment except DDT substituted for lead arsenate plus summer oil in third of five cover sprays.

2/ First and second covers, lead arsenate; third cover, lead arsenate plus summer oil emulsion; fourth and fifth covers, summer oil emulsion plus nicotine.

The data in table 1 shows that the codling moth infestation in both the Yellow Transparent and Williams Early Red blocks was low, averaging 5 percent or less total codling moth injury on both varieties in the standard sprayed plots. There was a reduction in both stung and wormy fruit on both varieties where DDT was used once at the rate of 1 pound to 100 gallons in the third cover spray to replace lead arsenate. The examination of dropped apples in the Yellow Transparent block shows nearly 7 times as many stung and wormy drops under 5 standard sprayed trees as were found under 5 DDT sprayed trees. No foliage or fruit injury was observed on any of the plots.

Experiments at Glassboro. The experiments at Glassboro were carried out in a block of Rome trees where codling moth injury had been severe in past years. The block of trees consisted of 15 rows of approximately 20 trees per row. The entire block received a petal fall and 4 cover sprays of lead arsenate or lead arsenate and oil plus 1/2 pint of nicotine to 100 gallons of spray in each of the 4 cover sprays. The different plot treatments were begun on June 27th at the time the 5th cover spray was due, at which time first brood egg hatching was about completed and before second brood egg laying had begun. Plot 1, consisting of one row of trees near the center of the block, was sprayed with 1 1/2 pounds of special Black Leaf 155 plus 2 quarts of summer oil (the special Black Leaf 155 was made with Mississippi Bentonite instead of Wyoming Bentonite). Plot 2, consisting of three rows of trees adjoining plot one, was sprayed with regular Black Leaf 155, 1 1/2 pounds to 100 gallons plus two quarts of summer oil. Plot 3, consisting of 5 rows of trees adjoining plot 2, was sprayed with Mississippi bentonite 8 pounds plus nicotine sulfate 1 pint plus summer oil 1 quart to 100 gallons of water. Plot 4, consisting of 6 rows adjoining plot 1, was sprayed with lead arsenate 3 pounds, lime 3 pounds plus summer oil 1 quart to 100 gallons.

An interval of two weeks elapsed between the first plot treatment (5th cover spray at end of first brood) and the second spray at the beginning of second brood on July 12. At that time plots 1, 2, 3 and 4 were sprayed the same as the first spray on June 27th. At this time a fifth plot, made up of 15 trees on one row in the standard lead arsenate plot was sprayed with 5 pounds of DDT-pyrophyllite (20-80) to 100 gallons of water plus 1/2 pound of soybean flour. Three additional sprays were applied against second brood codling moth on plots 1, 2, 3 and 4 on July 22nd, August 1st and August 12th. No additional spray applications were made on plot 5, the DDT plot.

To determine codling moth control on the various plots the writer selected 6 trees with uniform crops in each plot except plot 5 where only 3 trees were selected. Dropped apples under these trees were collected every 10 days from July 15th to harvest on October 11th and scored as clean or codling moth injured. At harvest the fruit remaining on the trees was scored in like manner.

The results from the combined drops and picked fruit are set forth in Table II.

Table II. Relative codling moth control on plots sprayed: (1) Special Black Leaf 155 plus oil; (2) Regular Black Leaf 155 plus oil; (3) Tank mixed Mississippi Bentonite plus 1 quart of oil; (4) Lead arsenate-oil and (5) DDT-Pyrophyllite (one spray application).

Tree	Plot Number									
	1		2		3		4		5	
No.	C	W	C	W	C	W	C	W	C	W
1	270	531	448	1143	152	714	130	877	359	1274
2	52	369	292	894	285	1182	90	828	199	803
3	283	1085	188	1039	315	940	170	1111	147	1021
4	291	980	134	652	217	1075	323	1088	--	--
5	257	647	394	1139	266	1183	340	1065	--	--
6	250	674	329	1326	472	1525	155	635	--	--
Totals	1403	4286	1785	6193	1707	6619	1208	5604	705	3098
Percent	24.6	75.4	22.3	77.7	20.5	79.5	17.7	82.3	18.5	81.5

W = Codling moth injury (worm holes and stings combined).

C = Clean (free of codling moth stings or worm holes).

The data in table 2 shows a high percentage of codling moth injury in all plots. This was not unexpected because a considerable number of first brood larvae got by the early first brood sprays. This was due, in a large measure, to the failure of the grower to spray from underneath the trees, especially in the first three cover sprays of first brood. Failure to cover the fruit thoroughly during first brood plus hot, dry weather during July and August added up to a heavy attack by second brood codling moth larvae.

Under the conditions encountered, none of the plot treatments gave a satisfactory control of second brood codling moth when applied at intervals of 10 days. Of the five spray combinations tested, the special Black Leaf 155 and oil was first with 24.6 percent clean fruit, followed by the regular Black Leaf 155 and oil with 22.3 percent clean fruit, followed by tank

mixed Mississippi bentonite-nicotine-oil with 20.5 percent clean fruit. The lead arsenate-oil was the poorest treatment with only 17.7 percent clean fruit. The one application of DDT-pyrophyllite applied July 12th held codling moth as well as the lead arsenate-oil which received three more spray applications than the DDT plot.

Experiments at College Farm. Preliminary spraying experiments with DDT were carried out on a few apple trees in the College Farm variety block in cooperation with Doctor Ginsburg of this Department. One tree of each of the five varieties: Winesap, Rome, Wealthy, Wagner and Starr were sprayed with DDT-pyrophyllite (20-80) 5 pounds to 100 gallons plus sulfur plus 1/2 pound soybean flour at the petal-fall and in four cover sprays against first brood codling moth. The remainder of the block was sprayed the same number of times with the standard treatment of lead arsenate, sulfur, lime and soybean flour. At the end of first brood codling moth attack counts on codling moth and curculio injury were made on the DDT sprayed trees and the lead arsenate sprayed trees. The results are set forth in Table III.

Table III. Percentage of codling moth and curculio injured apples on five varieties of apples sprayed five times with DDT compared to apples sprayed five times with lead arsenate.

Plot Treatment	Variety	No. Apples Examined	Percentage Apples Showing C.M. Stings	C.M. Worms	Curculio
DDT	Winesap	200	5.0	3.0	10.0
	Rome	200	1.0	1.5	19.5
	Wealthy	200	2.0	0.0	23.5
	Wagner	200	3.0	0.0	50.0
	Starr	200	2.5	0.5	17.0
Lead Arsenate	Winesap	200	13.0	9.5	9.5
	Rome	200	10.5	6.0	14.5
	Wealthy	200	6.0	4.5	18.5
	Wagner	200	18.0	6.0	45.0
	Starr	200	9.5	4.5	21.5

The data in table 3 shows that a petal-fall and 4 cover sprays of DDT (1 pound of DDT to 100 gallons) were superior to a petal-fall and 4 cover sprays of lead arsenate in controlling first brood codling moth on single tree plots of five varieties of apples. A rather high percentage of apples showed curculio stings in both the DDT and lead arsenate sprayed fruit. The data indicate that the DDT was a little less effective than the lead arsenate in holding down curculio injury.

A careful check was made from week to week throughout the season to see if any injury to fruit and foliage resulted from the DDT spray. None was observed. It was noted, however, that the European red mite built up much earlier on the DDT sprayed trees than on the lead arsenate sprayed trees. By the middle of July the foliage was bronzed from red mite on the DDT trees whereas the lead arsenate sprayed trees showed little or no bronzing and comparatively few mites. Two sprays of DN-111 were used to clean up the mite population on the DDT trees in mid-July after they had become bronzed from the heavy red mite feeding. The lead arsenate sprayed trees were also sprayed with DN-111 to prevent a build-up on those trees.

NEW YORK

S. W. Harman, New York State Agricultural Experiment Station, Geneva.

RESULTS OF CODLING MOTH INVESTIGATIONS IN WESTERN NEW YORK, 1944

I. <u>Seasonal conditions.</u>

The season of 1944 was unusually favorable for codling moth development making it necessary to use a full schedule of summer sprays for maximum protection against both first and second broods of worms. There was a good crop of apples produced by the better class of growers while on the other hand there was an abundance of wormy and scabby fruit where haphazard methods of control were practiced. If it were not for the high prices paid for apples it would not have paid to sttempt to raise clean fruit in certain sections where the heaviest infestations of codling moth occurred. Spiking lead arsenate sprays with nicotine during peak periods of worm activity is rapidly becoming a general practice.

II. <u>Control with sprays.</u>

As major interest centers in DDT materials this season the results of tests with sprays will be confined mainly to this material. The DDT used in the tests was Geigy's Gesarol AK20. At the concentration used it afforded protection almost identical with lead arsenate when applied at

10-day to 2-week intervals (Plots 1 and 2 in the table). When the interval between applications was increased to 3 weeks or more the control dropped appreciably (Plot 3). The addition of oil to the DDT spray appeared to increase the efficiency of the treatment (Plot 4).

Two nicotine sprays compounded at the Eastern Regional Research Laboratory will be of interest to workers who also tested these materials (Plots 5 and 6).

Codling Moth Control with Sprays, 1944

Plot	Materials 1/	Cover sprays	Stings on 100 apples	Worm holes in 100 apples
1	Lead arsenate 3 lb.	5	15	5
2	DDT 0.8 lb.	5	11	5
3	DDT 0.8 lb.	3	29	41
4	DDT 0.8 lb. DDT 0.8 lb. + oil 1 qt.	2) 3)	9	3
5	Lead arsenate 3 lb. Nicotine-copper-fatty acid 2/	2) 3)	34	33
6	Lead arsenate 3 lb. Cuprous nicotine cyanide 3/	2) 3)	29	34
7	Checks	0	22	137

1/ Amounts mentioned were used in 100 gallons of water.

2/ Sample No. 271 tested for Eastern Regional Research Laboratory, containing 8.1 percent nicotine.

3/ Sample No. 272 tested for Eastern Regional Research Laboratory, containing 13.9 percent nicotine.

Judging from the results of one year's orchard tests it appears that DDT may prove a good substitute for lead arsenate under western New York conditions. Used at the rate of 0.8 of a pound in 100 gallons control equal to that with 3 pounds of lead arsenate could be expected. Larger amounts may prove more effective than the arsenical. Although red mite has been reported as a serious pest in some parts of the country following the use of DDT, it has not been of major consideration in

western New York apple orchards in the past and results of one season's tests did not show any abnormal build-up following a DDT program. There was no apparent injury either to the trees or fruit following applications of DDT although a distinct bronzing was noticeable on the foliage late in the fall. There was little or no visible residue at harvest following five cover sprays and the cost at present is little more than that of lead arsenate. Undoubtedly DDT will never be used extensively on fruit until after a tolerance has been established. However, contrary to some of the early opinions, DDT residue appears to either weather off or possibly break down into a less toxic form following application. This thought is prompted by reason of the experience that DDT residue was apparently non-toxic to the codling moth and apple aphids following the lapse of a few weeks after application.

III. Control with dusts.

The second year's tests with dust for combatting the codling moth were fully as promising as those reported a year ago on Page 40, Part I of this report for 1943.

Codling Moth Control with Dust, 1944

Plot	Materials	Applications	Stings on 100 apples	Worm holes in 100 apples
1	Spray - lead arsenate 3 lb.	5	5	3
2	Dust - sulfur-lead arsenate-B. L. 155-oil 58-20-20-2	7	4	6
3	Dust - sulfur-lead arsenate-B. L. 155-oil 68-20-10-2	7	4	6
4	Dust - sulfur-lead arsenate-oil 68-30-2	7	4	6
5	Checks, untreated	0	17	99

Dusts were applied in the evening taking advantage of quiet and damp air, using 2 to 3 pounds per tree at each application with a Bean orchard duster. Under these conditions the dust deposit was nearly as noticeable as that of spray. Residue analyses at harvest showed the deposit to be in excess of the tolerance and very nearly equal to that on the sprayed fruit. There were from 20 to 25 trees in each dust plot and the yield was from 10 to 15 bushels per tree.

Largely because of the present labor shortage there has been increasing interest in the use of dust on tree fruits and during the past season a number of fine apple crops were produced with dust schedules in western New York orchards.

OHIO

C. R. Cutright, Ohio Agricultural Experiment Station, Wooster.

I. Seasonal conditions and codling moth abundance.

Following a cold April, the temperatures of all other months of the growing season were above normal. May was almost 6° and June 5° above normal. The codling moth thus got off to a flying start and in many Ohio orchards was never stopped. Despite a large crop, Ohio had its worst codling moth season since 1934.

Summary of Codling Moth Biology

	Wooster (N. E. Central)	Lorain (Northern)
	Spring-brood Emergence	
First moth	May 15	May 22
50%	May 22	June 1
Last moth	June 11	June 26
	Summer-brood Emergence	
First moth	July 5	July 17
50%	July 20	August 2
Last moth	September 1	August 25
	First-brood Larvae under Bands	
First larvae	June 18	July 2
Peak	July 5	July 17

II. Studies on codling moth behavior.

In the autumn of 1943 larvae were collected at different points in Ohio and brought to Wooster where they were placed in standard emergence cages to compare their emergence time and rate with that of Wooster larvae. At the end of first-brood emergence the data showed that in all cages, emergence started on the same date, the 50% emergence date was the same, and that the last moths appeared at the same time.

III. (a) Field control experiments were conducted at Waterville, in northwestern Ohio, and at Lorain in northern Ohio. At both places 30- to 40-year-old Jonathan trees were used, each treatment or schedule appeared on single tree plots replicated 5 times. Minor experiments were conducted at Wooster.

(b) All experimental trees produced heavy crops of fruit.

(c) The use of an experimental calcium arsenate produced rather severe foliage injury. Foliage was fair to good on all other plots. Numerous orchards in Ottawa County used schedules of lead arsenate and wettable sulfur, without lime. The results were generally good.

DN-111 or Fermate used with lead arsenate also produced good foliage.

Summer oil, 1/2 gallon, plus B. L. 155, 2 pounds per 100 gallons, in 7 cover sprays dulled the finish of the fruit to a marked degree. Fruit produced with a tank-mix Mississippi Bentonite-oil-B. L. 40 schedule was much better.

A. Control by insecticides.

Twenty-two different spray schedules were tested at Waterville.

Results from 8 representative treatments are given in the following table.

Waterville Data

No.	Schedule	Fruit Wormy	Fruit stung	Crop injured by Codling Moth
		%	%	%
1	Lead arsenate, 3 lb. calyx and 8 covers	45	73	83
2	Lead-oil, as above, with oil in 3 first-brood covers	34	66	78
3	Lead-oil-B. L. 155. Oil in 3 covers, B. L. 155 in 2.	31	64	74
4	B. L. 155, 2 lb., oil, 1/2 gal. 7 covers.	21	35	49
5	B. L. 155-oil, as above, plus Fermate	14	30	40
6	Lead arsenate, as in 1, plus DN-111, in 7 covers	50	78	92
7	DDT, 1 lb., in 8 covers	2	6	8
8	DDT, 1 lb., in 5 covers, alternate applications	21	24	40

Results with lead arsenate alone or with DN-111 were very unsatisfactory. When oil was added, and especially when oil and B. L. 155 was combined with lead, better results were secured, but they were still far from good.

Black Leaf 155 with oil or with oil-Fermate gave fair results but, as already noted, the finish of the fruit was dulled.

DDT was outstanding in codling moth control and will be further discussed.

Nine different schedules were used at Lorain, Ohio, and data from six plots follow:

Lorain Data

No.	Schedule	Fruit Wormy	Fruit Stung	Crop injured by Codling Moth
		%	%	%
6	Lead arsenate, 3 lb., calyx & 7 covers	14	24	33
1	Lead arsenate, as in 6, oil in 3 covers	8	16	21
3	Lead arsenate-oil-B.L. 155. Oil in 3 first-brood covers, B.L. 155 in 2.	6	12	16
4	B.L. 155, 2 lb. oil, 1/2 gal.	11	6	16
5	Tank-mix-Miss. Bent.-oil-B.L. 40	8	6	13
9	Flat-type lead arsenate, as in 6	8	17	22

Many of the differences in the foregoing table are not significant. Good control, without injury to fruit or foliage, was secured by several schedules. Note especially flat-type lead.

Experiments with DDT.

All DDT used on apple was furnished by the Du Pont Company. It was a water dispersible formulation of 25% DDT. It went into suspension readily and if added to the tank when nearly full of water did not foam unduly.

It was used alone, except in 3 of the cover sprays when flotation sulfur paste was combined with it as the fungicide.

There was no direct injury to the foliage or fruit. In fact, the finish of fruit was probably the best of any of the 22 schedules.

No data was secured as to its effects on parasites. In an experiment at Wooster, green lace wings were not noted on DDT-sprayed trees.

In the experiment at Waterville, DDT plots carried a heavier European red mite population than did any other plots. The foliage was injured but not to the point where it affected fruit finish or condition. At Wooster, however, very heavy mite populations developed on DDT-sprayed trees and injury was very severe. No other pests or insects became abundant on the DDT plots.

B. Experiments with different DN compounds sprayed on the trunks and scaffold branches of trees during the late dormant period reduced the emergence of moths approximately 50 percent.

IV. In 1944 several growers had difficulty in obtaining nicotine for orchard use. There were a few local shortages of lead arsenate but, generally, the standard insecticides were sufficient to meet most needs. Slow delivery of spray machinery parts caused some trouble.

OKLAHOMA

F. E. Whitehead, Oklahoma Agricultural Experiment Station, Stillwater.

The injury from codling moths in Oklahoma was less severe in 1944 than in 1943. It is thought that in a large measure this was due to (a) an unusually late emergence from hibernation and (b) an extremely small fourth brood.

The first moths from larvae kept in pupation sticks in the insectary appeared April 28, which is the latest appearance made in 14 years of such observations and the first moth taken in traps in the orchard was taken May 1. It seems probable that the late emergence and some unusually cool weather the latter part of August and early September prevented the appearance of the fourth brood of moths.

Codling moth trap records for the summer of 1942 and the entire season of 1943-44, indicate that under Oklahoma conditions traps are very good indicators of moth activity during the emergence of the hibernating generation but almost without value for the later generations. In each of the past three summers very small catches were made at any time after the first brood of moths disappeared and there was little if any correlation between the numbers of moths reared from worms taken under bands and the numbers trapped in the orchard.

The data collected in Oklahoma indicate that a smaller percentage of the first generation of codling moths hibernate under Oklahoma conditions than have been reported for other localities even at the same latitude. An exceedingly small percentage of the worms emerging previously to July 15, enter hibernation, but starting during the latter part of July hibernating forms begin regularly appearing. The percentage hibernating slowly increases until the middle of August and then climbs rapidly until September 1, after which time nearly 100 percent of all maturing larvae hibernate.

OREGON

Leroy Childs and R. H. Robinson, Hood River Branch Experiment Station, Hood River, and Oregon Agricultural Experiment Station, Corvallis.

Replicated Tests:

Spraying tests were continued at the Hood River Station in 1944, the results from which, together with materials used are summarized in Table I. Experiments S-1 to S-4 inclusive, were replicated three times; the balance were single plot tests. The combination of Phenothiazine 1/2 pound used with 2 pounds lead arsenate and soybean flour 1/3 pound to 100 gallons of water and kryocide used in the same manner, have resulted in better control of codling moth during the 3-year test than where lead arsenate 3-100 plus Fluxit was employed. Differences in control were less in 1944 than earlier, probably due to the fact regular "grind" Phenothiazine was used in the last three covers, whereas, all previous applications were made with the micronized material. The change made in the 1944 program, was made necessary due to the fact that micronized Phenothiazine was unavailable. During the past two years, somewhat better control has resulted where oil was used as an ovicide as compared to the regular program of lead and Fluxit. Previously little differences

usually occurred. It is believed the improvement resulted from an attempt to spray the under leaf surfaces where we have found the 75 percent of the codling moth eggs are deposited on the lower leaf surfaces of the Newtown apple, the variety used in these tests.

Table I. Summary of Codling Moth Tests, 1944

Exp. No.	Materials used 1/ 2/	1st Brood Injury 4/	Condition at Harvest 1943 Wormy	Stung	Clean	Clean	1942 Clean
		%	%	%	%	%	%
S-1	Phenothiazine 1/2 lb.-100 Lead arsenate 2-100 plus Soybean flour 1/3 lb.-100	4.8	2.6	11.7	86.6	88.4	90.5
S-2	Phenothiazine 1/2 lb.-100 Kryocide 2-100 plus Soybean 1/3 - 100	4.2	2.8	11.7	86.0	88.8	--
S-3	Lead arsenate 3-100 + Flux. 1st Cov., Lead arsenate 3-100 + 3/4% Shell light 2nd and 3rd Cov., Lead arsenate 3-100 + 1/2% Shell light 4th & 5th.	3.1	2.0	11.9	86.6	86.4	--
S-4	Lead arsenate 3-100 plus 1/4 - 100 Fluxit; all sprays	5.2	2.3	14.8	83.5	81.0	85.0
S-5	Lead arsenate 2-100 plus Soybean flour 1/3 - 100, all sprays.	8.0	4.9	16.9	80.6 3/	--	--

1/ Lead Arsenate, 3-100 plus 1/4-100 Fluxit used in Calyx spray in all tests.

2/ Spray dates: Calyx 5/12; covers 1st, 6/3; 2nd, 6/22; 3rd 7/6; 4th 8/13; 5th 9/8.

3/ One plot only.

4/ Worms and stings.

DDT. Single plots of three trees each were sprayed in various ways with DDT during 1944. Table II summarized the program used and the results obtained in codling moth control that followed. The material used in Experiments 1 to 3 inclusive, was obtained from DuPont and consisted of 25 percent dichloro diphenyl trichloroethane and inerts 75 percent. The trees in Experiment 4 were sprayed with a laboratory prepared mixture containing 20 percent DDT in Pyrophyllite containing a wetting agent, Eriopon N. The results obtained in the DDT plots were compared with a lead program in which oil was used in some of the applications and a straight lead program to which Fluxit spreader was

added. In these tests all parts of the trees were thoroughly covered, trunks, branches, lower leaf surfaces etc., as we were interested in the control of other pests, particularly the woolly aphis and effects on its predacious and parasitic enemies. Approximately 30 gallons per tree per application, were used. Codling moth control obtained with DDT phenominal. Not a single wormy apple was seen on the trees in Experiment 1, 2 and 3 all season. The final count indicated the same. The results obtained in Experiment 2 are of particular interest as no spray was applied after the third cover. Visible spray persists until harvest, particularly on the foliage.

While checking for first brood control, numerous hatched eggs were found in the DDT plots as well as where the regular program was employed. These observations indicate that DDT does not materially affect moth activity and furthermore the material does not prevent hatching. The spray stops the young worms before they can feed upon the fruit to any noticeable extent as stings were likewise of little importance in the DDT tests. The few that were found were, for the most part, very shallow and often hardly noticeable.

Table II. Codling Moth Control - DDT - Tests, 1944

Exp. No.	Materials Used 1/	1st Brood Injury per 100 Apples	Condition at Harvest: Wormy Apples	Condition at Harvest: Stung Apples	Condition at Harvest: Clean Apples
		%	%	%	%
D-1	1st cover 1 lb. - 100 DDT 2/ 2nd, 3rd, 4th, 5th, 1/2 lb. - 100 DDT 4/	.1	.0	.57	99.4
D-2	1st. cover 2 lb. - 100 DDT 2nd and 3 covers 1 lb. - 100 DDT No further sprays applied.	.0	.0	.4	99.6
D-3	Same as D-1 plus 1 qt. - 100 Shell light emulsive oil.	.5	.0	1.05	98.9
D-4	1st cover Lead ars. 3-100 plus 1/4 - 100 Flux. 2nd, 3rd, 4th, 5th, 2/5 lb.-100 DDT plus Colloidal 77, 1/3 lb.-100 3/	2.6	.34	2.2	97.7
D-5	1st & 5th covers Lead ars. 3-100 Flux. 1/4-100; 2nd & 3rd Lead ars. 3-100 plus Shell light 1%; 4th same with 1/2% oil.	7.9	2.1	13.0	85.9
D-6	Calyx and 5 covers Lead ars. 3-100 plus Fluxit 1/4 - 100.	10.5	2.3	19.5	79.6

1/ Calyx spray in all tests 3-100 lead arsenate, plus 1/4-100 Fluxit.
2/ Dilution in all tests is actual DDT.
3/ 20 percent DDT.
4/ Spray dates; Calyx 5/10; 1st cover 6/5; 2nd 6/20; 3rd 7/6; 4th 8/13; 5th 9/7.

No injury to fruit or foliage occurred in the DDT plots. Leaves persisted late into the fall in a manner similar to that found in the regular spray program.

Other factors: Observations were made on other insects affecting apples in this district. Two species of leafhopper, Empoa rosae and Empoasca unicolor, were completely eliminated. On the other hand, the woolly apple aphis built up to very serious proportions. Although no mortality studies were made, it is apparent DDT exerts little or no control of this pest. Build-up of woolly aphis population results from the elimination of several predators and the parasite Aphelinus mali. The predators include at least two species of syrphid flies - lace wings and one or more species of lady beetles. A biological upset in the apple orchards of the mid-Columbia area of this character, would constitute a serious problem as the woolly aphis is associated with the spread of a fungus disease Gleosporium perennans which gave promise of eliminating apple orchards of this area. The introduction of Aphelinus in 1928 so reduced and controlled the woolly aphis canker that it has been of minor importance since that time. Because of this situation alone, the use of DDT appears questionable as an apple spray. Further investigation may permit modification of this point of view. Table III roughly expresses the differences in aphis population noted in the various tests.

Mites: The two-spotted or Willamette mite, often causing noticeable injury in this area on both apples and pears, failed to cause serious injury in the plots during 1944. In the DDT plots noticeable population increase occurred in September which resulted in some leaf yellowing, particularly on the lower inside leaves. Had mite activity started earlier in the season, doubtless serious damage would have occurred where DDT was employed.

THE REMOVAL OF DDT SPRAY RESIDUE FROM APPLES AND PEARS.

Chemical laboratory experimental washing tests were carried on using Newtown apples that had received three cover sprays of DDT and carried .21 grain per pound. Various chemicals and mixtures of chemicals were used including light oils and oil emulsions in different concentrations in water. The fruit was washed for either a period of one minute or three minutes at temperatures ranging between 80° F. and 105° F. From the laboratory results obtained thus far, no solvent, or mixture of solvents has removed the DDT below .036 grain per pound. The fact that water containing one of the wetting agents was as effective in taking off the residue as any of the other solvent mixtures tested indicates that the latter has no dissolving action on the DDT but rather only a detergent effect.

In commercial washing tests, Newtown apples taken from the experimental plots at Hood River at harvest time were washed in both a Cutler and an Ideal machine. The table indicates the conditions of the washing treatment and the results obtained.

Table III. Effects of DDT on Woolly Aphis Population on Sucker Growth - Newtown Apple.

Exp. No.	Material Used.	Interspaces (1) Total Examined.	With Aphis	% with aphis	
D-1	1st cover 1 - 100 DDT (2) 2nd, 3rd, 4th, 5th, 1/2-100 DDT	1531	1283	84.0	Very abundant
D-2	1st cover 2 lbs. - 100 DDT 2nd and 3rd, 1 - 100 DDT No further sprays applied.	1195	788	66.0	Abundant
D-3	Same as D-1 plus 1 qt. - 100 Shell light emulsive oil	1527	1220	80.0	Very Abundant
D-4	1st cover Ars. L. 3-100 Flux. ¼-100; 2nd, 3rd, 4th, 5th, 2/5 lb. - 100 DDT plus Colloidal 77, 1/3-100.	1438	697	48.5	
D-6	Calyx and 5 covers, Arsenate of Lead 3-100 plus Fluxit ¼ - 100	1828	89	4.9	Usually an occasional aphis.

(1) Unit used for determining infestation was the space between leaves on sucker growth. This method does not adequately express total population as on many shoots sprayed with DDT were covered three or four deep with aphids, whereas, on the regularly sprayed trees, only an occasional aphid was found.

(2) Actual DDT.

Although the laboratory experimental washing tests showed no solvent that was outstandingly effective for the removal of DDT residue, yet washing tests were carried on at harvest time using Newtown apples that had been harvested the previous day. As indicated in the Table, 1.5 percent hydrochloric acid was already in a Cutler and an Ideal machine. The temperature was then adjusted to 75° F. and the fruit put through the washer. The hydrochloric acid was used only because it was already in the machine and it was not expected that it would have any solvent effect. In like manner the temperature was raised to 100° F. and fruit put through the wash. Also Vatsol was added to both machines until the acid solution foamed excessively without, however, lifting out of the machine. Again in another machine, carotene, one gallon to the 100, was added to the hydrochloric acid and fruit put through the washer. From the results it is apparent that there was a mechanical removal of the residue where acid alone was used and a slight detergent effect where Vatsol was used. It is questionable whether the kerosene removed any of the DDT much more effectively than did the acid solution alone since the results could be within experimental error of the selection of the samples for washing. Examination of the apples indicated that perhaps the kerosene may have dissolved a certain amount of the residue and then redistributed it as a thin film in the oily phase left on the apple after leaving the machine.

Pears from the Southern Oregon Branch Experiment Station were also washed commercially in order to learn to what extent the residue of DDT could be removed. The Bartlett pears were sprayed experimentally by Mr. Gentner, entomologist of the Branch Experiment Station, and put through a Bean fruit washer with the acid testing about 1.5 percent at prevailing water temperature of the machine which was about 70° F. Duplicate samples of these pears were put in storage and at the time the apple washing tests were carried on at Hood River, the pears were put through the Cutler and Ideal machines under the condition indicated in the table. The results with the three different commercial washing machines, indicate that there was practically no removal whatsoever of residue from the fruit. Where the analyses indicated .032 grain DDT per pound before washing, the pears had been sprayed in the last three cover sprays with .4 pound DDT containing a little wetting agent. Where the analysis indicates .042 grain DDT per pound, the pears had been sprayed in the last three cover sprays with .6 pound of DDT to the 100 gallons containing a little wetting agent. The results show that within experimental error practically none of the DDT had been removed by any of the washing treatments. Examination of the pears at the time of washing showed that the small visible residue blended into the waxy surface of the fruit and rubbing with the fingers did not remove it.

Concluding from both the laboratory and commercial washing tests, it is evident that cleaning fruit of DDT will be difficult unless a very high tolerance is established for the insecticide.

WASHING TESTS FOR REMOVAL OF DDT FROM NEWTOWN APPLES

Washer	Treatment	DDT Before Wash. gr./lb.	DDT After Wash. gr./lb.
Cutler	HCl 1.5% at 75° F.	.061 1/	.046
Ideal	HCl 1.5% at 75° F.	.061	.045
Cutler	HCl 1.5% at 100° F.	.061	.043
Ideal	HCl 1.5% at 100° F.	.061	.037
Cutler	HCl 1.5% + Vatsol to excess foam, 100°F.	.061	.034
Ideal	HCl 1.5% + Vatsol to excess foam, 100°F.	.061	.037
Cutler	HCl 1.5% + kerosene 1%, 100° F.	.061	.047
Ideal	HCl 1.5% + kerosene 1%, 100° F.	.061	.052
Cutler	HCl 1.5% + kerosene 1%, 100° F.	.059 2/	.057
Ideal	HCl 1.5% + kerosene 1%, 100° F.	.059	.041
	PEARS		
Bean	HCl 1.5% at 70° F.	.032	.029
Cutler	HCl 1.5% + Vatsol to excess foam, 100°F.	.032	.028
Bean	HCl 1.5% at 70° F.	.042	.046
Cutler	HCl 1.5% + Vatsol to excess foam, 100°F.	.042	.037
Cutler	HCl 1.5% + Vatsol to excess foam	.032	.031
Ideal	HCl 1.5% + Vatsol to excess foam	.042	.040

1/ Five cover sprays DDT .5 lb. to 100 gallons.
2/ Five cover sprays DDT (.5 lb. in 1 qt. oil) to 100 gallons.

SPRAY DEPOSITS OF DDT, ARSENIC, PHENOTHIAZINE, AND FLUORINE ON NEWTOWN APPLES FROM THE HOOD RIVER STATION EXPERIMENTAL PLOTS

Chemical analyses were made for the amount of spray deposits on Newtown apples from the Hood River Station experimental plots. A representative sample from each plot was collected before and after the third and fifth cover sprays and at harvest time. The results, together with a description of the sprays used, are given in the table. The chemical method used for the analysis was a modification of the Winter method for the determination of chlorine in organic compounds. The modification adapted the method for the determination of small amounts of DDT. The Gunther method was also used and checked sufficiently close to the other method.

The results show that the amounts of DDT deposited upon the apples depended upon the spreader treatment used and the quantity per 100 gallons of spray. It is apparent that the lasting qualities of DDT are similar to the arsenical and fluorine compounds in that any losses may be attributed to increase in size of apple, rainfall or other erosion agencies. There is no evidence of chemical decomposition from exposure to sunlight or to other conditions. This is further confirmed in that no DDT spray was applied to plot D-2 after July 6, yet control was practically 100 percent. Since decomposition of DDT has been reported in other parts of the country, it may be that conditions at Hood River may account for the lasting effects of DDT. Most significant among these conditions is the very low salt content of the spray water used in the Valley and the absence of alkaline dust that fills the air in most fruit-growing districts. The presence of iron and other salts may cause breakdown of DDT and in their reaction possibly cause plant injury. It is not yet known what chemicals will cause decomposition of the DDT when present in relatively small amounts.

Judging from the control obtained with DDT it would seem that a spreader that would produce wetting of both fruit and leaves quickly and over the entire surface, leaving a very thin film of the DDT, would be most effective and practicable. The various wetting agents will suffice for this purpose. It is questionable whether depositing agents or oil would be of any value.

Spray deposits of phenothiazine when combined with either lead arsenate or Kryocide gave deposits similar to previous observations and depending largely upon rainfall that occurred in June or prior to harvest. This also applies to experimental plots where lead arsenate was used with Fluxit and soy flour as spreader.

DDT, Arsenical, Phenothiazine and Fluorine Spray Deposits on Newtown Apples
From Hood River Station Experimental Plots

Plot	Spray Treatment	Micrograms per sq. cm. 3rd Cover Before	3rd Cover After	5th Cover Before	5th Cover After	At Harvest
D-1	Lead Ars. 3-100 + Flux. 1/7-100 in Calyx; DDT + wetting agent 1-100 in 1st cover - 1/4-100 in other covers.	DDT-4.9	10.1	8.3	14.5	7.3
D-2	Lead Ars. 3-100 + Flux. 1/4-100 in Calyx; DDT + wetting agent 2-100 in 1st cover and 1-100 in 2nd and 3rd. No spray applied at 4th and 5th cover.	DDT-10.0	18.3	7.2	7.2 1/	4.9
D-3	Lead Ars. 3-100 + Flux. 1/4-100 in Calyx ; DDT + 1-100 in 1 qt. light oil in 1st cover; DDT 1/2-100 in 1 qt. oil, in other covers.	DDT-7.6	11.1	12.6	17.3	7.3
D-4	Lead Ars. 3-100 + Flux. 1/4-100 in Calyx & 1st cover; DDT 2/5-100 + Coll. 77; 1/2-100 in other covers.	DDT-2.0	7.9	6.6	11.3	4.0
S-1	Lead Ars. 3-100 + Flux. 1/4-100 in Calyx; Lead Ars. 2-100 + Phenothiazine 1/2-100 + Soy flour 1/3-100, in 5 covers	AS_2O_3-3.7 Phen.-2.5	8.3 5.3	9.8 3.5	12.7 9.3	15.1 2.9
S-2	Lead Ars. 3-100 + Flux. 1/4-100 in Calyx; Kryocide, 2-100 + Phenothiazine 1/2-100 + Soy flour 1/3-100 in 5 covers.	FL-6.3 Phen.1.9	18.1 5.6	9.0 3.1	21.1 9.0	12.0 2/ 2.9
S-4	Lead Ars. 3-100 + Flux. 1/4-100 in Calyx; and 5 covers.	AS_2O_3-9.2	14.9	15.1	24.4	16.0
S-5	Lead Ars. 2-100 + Soy flour 1/3-100 in Calyx and 5 covers.	AS_2O_3-4.9	10.9	9.1	15.4	12.0

1/ No spray applied after 3rd cover.

2/ As spray residue .092 grain Fluorine per pound.

OREGON (Continued)

L. G. Gentner, Southern Oregon Branch Experiment Station, Talent.

Results of Codling Moth Investigation, 1944

The spring of 1944 was unusually uniformly cool, with few days favorable for bee flight during the blooming period. The summer was also generally cooler, with the month of September quite warm. Codling moth development was slow and irregular, without a definite division between the first and second broods. Fruit harvest was about three weeks later than normal.

Because of other work, only limited tests were carried on for codling moth control. The same orchard of commercial Bartlett trees was used as in previous years. The trees are 39 years old, smaller than average, and not uniform in size. All plots received a calyx and five cover sprays. The calyx and first two cover sprays were applied by the grower. Only the last three cover sprays were applied experimentally. Dates of application were as follows: 3rd cover, June 29; 4th cover, July 31; 5th cover August 17. The pears were harvested September 7.

Each plot consisted of eight trees--four random replicates of two trees each. All of the fruit, both from the tree and on the ground, from all trees in each plot was examined for worm injury. Sprays were applied with a Bean portable sprayer at a pressure of 400 to 450 pounds at the pump, using two leads of hose and single spray guns with 7/64 inch openings in the discs. About 12 gallons of spray were used per tree per application.

Plot Treatments

Plot 1* - 2 lb. Gesarol AK20 (DDT), 1/4 lb. Colloidal 77, 1 qt. stove oil in 3rd, 4th, and 5th covers.

Plot 2* - 3 lb. Gesarol AK20 (DDT), 1/4 lb. Colloidal 77, 1 qt. stove oil in 3rd, 4th, and 5th covers.

Plot 3* - 3 lb. Lead arsenate, 1/4 lb. Multi-Film, 1 qt. stove oil in 3rd, 4th, and 5th covers.

Plot 4* - 1/4 lb. Multi-Film, 3 lb. lead arsenate, 1 qt. stove oil in 3rd, 4th, and 5th covers.

*All plots received a calyx and first two cover sprays of 3 pounds lead arsenate and 1/3 pound Z-1 deposit builder, applied by the grower.

Control in Commercial Bartlett Orchard

Plot 1 - Three old calyx entries and 4 old entries, a total of 7 wormy fruits in 7,119 or approximately 1 in 1,000.

Plot 2 - One old calyx entry, or 1 worm in 5,775 fruits.

Plot 3 - Four calyx entries and 23 side entries, a total of 27 wormy fruits in 5,328, or 1 in 194. (About 1 in 200.)

Plot 4 - Six calyx entries and 43 side entries, a total of 49 wormy fruits in 5,298, or 1 in 108. (About 1 in 100.)

Neither the fruit nor the foliage was injured by any of the treatments used.

With Gesarol AK20 the deposit was spotted with light underlying film. It appeared somewhat like the cover obtained with straight lead arsenate. With lead arsenate the type of deposit varied with the order of mixing. In plot 4, where the deposit builder was added to the tank first, the deposit was noticeably lighter and consisted of a light underlying film with heavier spotting. In plot 3, where the lead arsenate was added to the tank first, the deposit was noticeably heavier and of a uniform film type. Analysis of the fruit at harvest time showed 63 percent higher deposit in plot 3 than in plot 4.

No difficulty was experienced in removing the lead arsenate residue from the fruit, however, practically no DDT was removed in an acid wash of 2 percent strength, as is shown in the table.

Deposit and residue analyses were made by R. H. Robinson, Chemist, Oregon Experiment Station, Corvallis. At harvest time two lots of 15 pears each were selected from each plot. One lot was left unwashed as a check and the other was washed in an unheated acid bath at 2 percent strength.

DDT and Arsenic Residue on Pears

Plot No.	D D T			As_2O_3		
	As Deposit	Before Wash.	After Wash.	As Deposit	Before Wash.	After Wash.
	mic./sq.cm.	grain/lb.		mic./sq.cm.	grain/lb.	
1	4.7	.032	.029	--	--	--
2	6.0	.042	.046	--	--	--
3	--	--	--	9.8	.152	.004
4	--	--	--	6.0	.094	.004

Lead Arsenate. This material must still be considered our most practical insecticide for codling moth control. Very good control is usually obtained when other materials are added to improve the deposit and coverage. In extreme cases it may be necessary to add an ovicide. Results in plots 3 and 4 indicate that under certain conditions certain lead arsenates will put on a much heavier deposit when used with a deposit builder, if the lead arsenate is added to the tank first.

One of the outstanding objections to lead arsenate is its accumulation in the soil. Fruit growers are becoming increasingly apprehensive of this harmful residue. In some of the older orchards it is becoming more and more difficult to grow a vetch cover crop, and on land cleared of fruit trees crops may suffer for many years. From this standpoint an acceptable substitute would be very desirable.

DDT. Tests with this material in the form known as Gesarol AK20 showed it to be very effective in codling moth control. It was not possible to obtain this material before the third cover spray, but as nearly as could be determined there was not a single worm entry after application of this material. However, the residue removal from the fruit presents a difficult problem. Practically none of the material was removed in a cold, 2 percent acid wash. Apparently this material has no effect in controlling spider mites. A heavy infestation of two-spotted and Willamette mites developed on the Bartlett trees with considerable foliage injury in evidence at the time of application of the fifth cover spray. The injury was just as serious on trees sprayed with DDT as on those sprayed with lead arsenate. A spray of 3/4 pound DN-111 and 1/3 pound Z-1 deposit builder applied the day after the fifth cover spray completely controlled the mites and caused no injury.

The DDT used experimentally was supplied by the Geigy Company as Gesarol AK20. This was in the form of a white powder containing 20 percent DDT in a finely divided state. To form this product the DDT was milled in the presence of a very finely divided, easily wettable inert.

PENNSYLVANIA

H. M. Steiner, Pennsylvania Agricultural Experiment Station, Arendtsville.

SEASONAL DEVELOPMENTS

Cold wet weather in March and April was followed by a warm May 7°F. above average. The remainder of the growing season was hot and dry. Spring moth emergence began in cages at petal-fall of Red Delicious May 11, reached a peak at petal-fall of Rome Beauty on May 17 and continued to June 17. Emergence continued in some orchards until June 30. Moths were taken almost daily in bait pails from May 12 to October 2 with peak catches on May 23. Hatching began on May 26 and continued in some orchards over a span of 125 days. Several orchards, with many worms from 1943, had 20 to 30 percent injured fruits by June 5. A large second brood was followed by

a partial third brood in many orchards on the sides of low hills. Wormy fruits in local sprayed orchards averaged near 20 percent of the crop compared to approximately 10 percent in 1943 and 5 percent in 1942. In many orchards, where codling moth was not controlled in 1943, practically all fruits were stung in 1944.

TESTS WITH INSECTICIDES

Two sites were used for comparisons of spray schedules. They were located 1/4 miles apart at about 750 feet on gentle East and West slopes of the same hill range. Each had a large carry-over of worms from the previous year when harvested fruits had averaged near 50 percent wormy and 90 percent stung after 5 and 7 cover sprays had been applied by the growers. In these blocks, spring brood moth captures averaged 749 and 599 per double quart trap in baited trees around the East and West blocks respectively.

The trees were 20 to 24 feet high. They set light crops of about 1/3 less fruits than in 1943. The numbers of June drops averaged less than 10 percent of the fruits.

The East block measured 8 by 12 rows and the West block 2 by 15 rows, each surrounded on 4 sides by heavily infested trees. Designations of trees for treatment was delayed until after a uniform first cover spray was applied. Trees of each first brood treatment were numbered in such manner that they would average to about equal prospects and to about equal average trunk diameters 12 inches above ground.

Differential sprays against first brood were applied in second and third covers only with a long period after third cover to permit breakdown in protection. These sprays were applied to the inside from the ground and from the tower to the outside of trees. In the East block, these two covers were applied 10 days apart and in the West block, 15 days apart. Eight trees, distributed in replicates through each block were used for first brood treatments. In the West block 4 trees of each of 3 first brood treatments was followed by a commercial nicotine schedule and 4 trees of the same first brood treatments received a USDA tank-mixed nicotine bentonite schedule.

All drops were scored, usually at weekly intervals, from the beginning of June drop to harvest. Samples of tree fruits and of harvested fruits were scored.

Table 1. Weather, moth emergence and bait catches at weekly intervals in test orchards at Arendtsville, Pa. 1944.

Week Ending:	Max. °F.	Mean °F. at 8 PM.	Rain Inches:	Moth (cage) Emergence:	Weekly bait pail catches: * East slope:	West slope:	Per cent females:
May 1	83	55	0.91	-	-	-	-
May 8	87	60	1.34	-	-	-	-
May 15	88	67	trace	64	74	18	47
May 22	89	65	1.54	364	797	1075	29
May 29	85	65	0.39	201	829	983	35
June 5	89	67	0.06	204	757	352	42
June 12	86	64	0.36	100	592	198	25
June 19	95	70	0.55	28	361	176	38
June 26	89	69	1.14	-	143	78	41
July 3	95	76	0.18	-	91	59	46
July 10	97	75	-	4	33	27	68
July 17	97	75	0.66	61	32	31	60
July 24	92	68	0.32	74	74	161	56
July 31	94	75	0.45	151	175	185	51
Aug. 7	99	77	0.66	142	384	226	42
Aug. 14	101	75	0.07	34	285	49	47
Aug. 21	97	75	-	21	297	270	48
Aug. 28	88	70	0.43	8	91	110	41
Sept. 4	92	70	0.87	11	126	117	43
Sep. 11	86	61	trace	22	31	58	65
Sep. 18	81	67	2.19	-	22	16	74
Sep. 25	83	60	0.58	-	13	8	90
Oct. 2	79	57	0.51	-	13	38	80

* Double quart traps of paired baits were used. The traps were baited with 10% No. 13 brown sugar solution plus 1 cc nicotine sulfate per quart. ½ cc. oil of sassafras was added to one quart jar of each double trap. The baits were changed between broods. They were refilled with fresh 5% brown sugar solution whenever evaporation reduced contents to less than one half. Nicotine sulfate was added at this time. Five double traps were used on each slope. Of the total 9465 moths taken in 10 traps, 5566 were taken in the sides containing oil of sassafras.

Table 2. Influence of 2 cover sprays on variations in codling moth injury by different first brood schedules: East slope orchard. Stayman.

*Materials and rates per 100 gals: Second cover: 5/30/44 Third cover: 6/9/44	Total fruits per tree:	Tree counts of Injuries per 100 fruits: May 30 to June 21:	May 26 to July 25:	Total per tree in drops to July 25, 1944: Worm Holes:	Stings:
Calcium arsenate 3 lbs. Flake Zinc sulfate 1 lb. Spray lime 2 lbs.	788	185	351	127	243
Lead arsenate 3 lbs. Flake Zinc sulfate 1 lb. Spray lime 2 lbs.	835	180	313	114	229
Lead arsenate 3 lbs. Nicotine sulfate ½ pt. Fermate ½ lb.	798	126	252	56	105
Lead arsenate 3 lbs. B. L. 155 2 lbs. Fermate ½ lb.	736	90	204	44	93
Lead arsenate 3 lbs. Phenothiazine ½ lb.	749	65	206	50	84
Lead arsenate 3 lbs. Phenothiazine 1 lb.	864	52	188	37	44
Lead arsenate 3 lbs. Phenothiazine 1½ lbs.	719	35	156	31	39
Lead arsenate 3 lbs. Phenothiazine 2 lbs.	735	12	135	11	14
Lead arsenate 3 lbs. Phenothiazine 2 lbs. DN-111 ½ lb.	846	14	123	19	17

* The petal-fall spray was applied by the grower May 12. A uniform first cover consisting of lead arsenate 4 lbs, Nicotine sulfate ½ pt. Fermate ½ lb. per 100 gallons of spray was applied to all trees on May 22 before differential treatments began.
A 4th cover was applied over all treatments from the outside only on June 26. It included lead arsenate 3 lbs. copper sulfate ½ lb. spray lime 2 lbs. Othol K 3 qts. Two second brood sprays were applied on July 18 and August 8 with the same materials and concentrations used in 4th cover.

Table 3. Full season comparisons of spray schedules with 34 days between first and second brood sprays. West Slope. Variety-Red Delicious.

* Materials and rates per 100 gallons: Second Cover 5/29 Third Cover 6/13:	Second brood sprays: 7/17: 7/28: 8/9:	Total fruits per tree: (Ave. 4 trees)	Per cent clean:	Per cent wormy:	Number per 100 fruits: Worm holes:	Stings:
Actual DDT ½ lb. (in DuPont formulation). Fermate ½ lb. Lead arsenate 3 lbs.	No second brood sprays:	1032	15	81	272	73
	Second Br. Sch.#1-	1723	48	29	46	69
	Second Br. Sch.#2-	893	54	27	40	43
Phenothiazine 2 lbs. Lead arsenate 3 lbs.	Second Br. Sch.#1 -	1449	48	28	44	62
	Second Br. Sch.#2 -	1783	59	25	35	38
B.L. 155 2 lbs. Fermate ½ lb. Lead arsenate 3 lbs.	Second Br. Sch.#1	1831	35	31	45	134
	Second Br. Sch.#2	1634	46	27	39	86
Lead arsenate-nicotine sprays as applied by the grower in 7 covers. Included only to show degree of infestation.		1825	6	37	66	489

* Second Brood Schedule No. 1 consisted of Black Leaf 155, 1½ lbs. Nicotine sulfate ½ pt. Orthol K - 3 qts. per 100 gallons of spray.

Second Brood Schedule No. 2 consisted of Nicotine sulfate 1 pt. Mississippi X110 Bentonite 8 lbs. Orthol K - 3 qts. per 100 gallons of spray.

Two sprays of Orthol K 2 qts. and nicotine sulfate ½ pt. were applied against 3rd brood to all trees on August 21 and September 5, 1944.

The petal fall spray was applied May 11, 1944. It contained Flotation sulfur paste 6 lbs.
Fermate ½ lb.
Lead arsenate 3 lbs.
Crystal Urea 5 lbs.

The first cover spray was applied May 23, 1944. It contained Flotation sulfur paste 6 lbs.
Fermate ½ lb.
Lead arsenate 4 lbs.
Nicotine sulfate 3/4 pt.

Table 4. Progressive attack on trees sprayed with materials as outlined in table 3. Counts on 8 trees per treatment. West Slope, Red Delicious.

Differential treatments against first brood in two cover sprays and rates per 100 gallons of spray:	Stung and wormy fruits: Accumulated mean per cent injured fruits by dates: May 29:	June 5:	June 12:	June 19:	June 26:	July 3:	July 10:	July 17:
DDT $\frac{1}{2}$ lb. Fermate $\frac{1}{2}$ lb. Lead arsenate 3 lbs.	0	3	3	3	5	5	12	18
Phenothiazine 2 lbs. Lead arsenate 3 lbs.	1	1	1	2	6	8	11	15
BL 155 2 lbs. Fermate $\frac{1}{2}$ lb. Lead arsenate 3 lbs.	1	10	13	15	19	24	30	34
Grower sprayed trees:	2	28	34	47	56	67	74	--

Table 5. Progressive accumulation of worm holes in drop fruits and of worms in bands from differential first brood treatments followed by nicotine-oil sprays for later broods.

Same treatments and rates of Table 4.	Ave. fruits per tree on 8 count trees per treatment:	Accumulated total worm holes per tree in drop fruits for the period extending from May 29 to: July 10:	July 31:	Aug. 21:	Sept. 11:	Harvest: Sept. 30.
DDT-Lead arsenate	1308	2	7	54	167	259
Phenothiazine-Lead Ars.	1616	1	12	62	161	283
BL-155-Lead ars.	1758	4	54	153	286	394
		Accumulated total worms in bands on the dates given above: Average per tree:				
DDT-Lead arsenate		0	2	8	21	27
Phenothiazine-Lead arsenate		0	0	1	8	10
BL 155-Lead arsenate		0	3	11	23	28
Unsprayed trees in a nearby orchard with a light carry-over of worms to 1944 equal to approximately 1/10th the number at the experimental site:		53	134	166	277	389

Spray injury and correctives: Some arsenical injury developed on trees sprayed with lead arsenate in the West block in September. Yellowing of cluster bud leaves was pronounced on all of these trees immediately after application of the first of the second brood treatments but defoliation before October was confined only to these leaves. Scalding of the skin of the fruit occurred on all trees sprayed with nicotine-oil in second brood but the injury amounted to less than 2 percent of the fruits and was least severe on trees that received the USDA tank-mixed nicotine bentonite.

The addition of DN-111 as a safener against arsenical injury in pheno-lead arsenate sprays in the East block was of doubtful value as there was no visible injury from other mixtures for comparisons and the prevalence of a wetting agent in the mixture may be undesirable in wet seasons.

Three year old peach were sprayed with pheno-lead and other combinations to study safeners that may be needed with the mix in wet seasons. Two pounds of pheno added to 3 pounds of lead arsenate per 100 gallons of spray was as effective in delaying defoliation of peach as 2 pounds of spray lime but neither pheno nor lime were adequate safeners on peach. A proprietary zinc, Delmo-Z, greatly delayed defoliation of peach when 1 pound per 100 gallons of spray was added to a 2-3-100 pheno-lead mix.

Red mites and aphids: On trees that had received oil at delayed dormant for red mite and had less than 1 mite or mite egg per 100 leaves on June 1, counts in mid-July on trees sprayed with DDT-lead arsenate (West block) had an average of 15 mites and 23 eggs per leaf. At the same time, trees sprayed with pheno-lead had an average of 3 mites and 2 eggs per leaf, while trees sprayed with BL-155-lead and Fermate had an average of 5 mites and 6 eggs per leaf. The mite population in this and adjacent orchards declined rapidly after mid-July. Greatest mite increases occurred between June 1 and June 25. On June 25, the few mites found on trees sprayed with pheno-lead had a bloated appearance and were much less active than the more numerous mites on other plots. Oil sprays at delayed dormant and nicotine sprays at first cover had reduced the predators [redacted] *Diaphnidia pellucida* and *Hyaliodes vitripennis* to insignificant numbers before differential sprays were applied in 2nd and 3rd covers. The early absence of other predators on all plots during the period of rapid mite increase does not explain the increase in mite populations on some plots over others. The lady beetle, *Stethorus punctum*, was most abundant on DDT sprayed trees in mid-July but it was not numerous enough to account for the rapid decline in numbers of mites in late July.

Green aphids increased on terminals of trees sprayed with phenothiazine-lead arsenate in the West block wherein trees sprayed with either DDT-Lead or BL 155-Lead were free from aphids. However, aphids declined rapidly in numbers on the pheno-lead plot about 2 weeks after third cover and produced no objectionable injury. Aphids were not numerous on trees that had received pheno-lead combinations in the East block.

Plum curculio: The failure of codling moth poisons such as phenothiazine, DDT or nicotine to control plum curculio necessitates the use of lead arsenate in all test sprays at petal-fall and in some of the later cover sprays until a safer or more effective substitute is available to replace lead arsenate for curculio.

Phenothiazine - lead arsenate in commercial orchards:

Pheno-lead combinations will be used in some of the heavily infested codling moth orchards of Southern Pennsylvania in 1945. On the basis of available information, we have suggested that:

1. Micronized, unconditioned, green phenothiazine be of an average particle size of 4 to 5 microns, none over 10 microns and that it contain no added agents:
2. It should be used with a straight lead arsenate:
3. Two lbs. pheno and 3 lbs. lead should be mixed dry before pasting with 5 pints water for each 100 gallons of spray:
4. In pasting, add water slowly, while stirring briskly and patiently thru the crumbly stage before making a smooth paste. This can be done with pail and paddle but a concrete mixer saves time in mixing large batches:
5. Add the paste to a near-full tank of water with the agitator running. (Carefully mixed pheno-lead will not layer on settling as does a hastily prepared mix and it will stir up as well in pipe lines or sprayers as lead arsenate if allowed to settle):
6. Pheno-lead is suggested for use in 3 sprays that cover the greater part of first brood hatching (locally in an average season on about 17, 27 and 37 days after petal-fall of Stayman and earlier on later blossoming varieties when median dates are considered for applications requiring several days to get over the orchard):
7. Nicotine sulfate may be added, if needed for leafhoppers and aphids, in one or more of these sprays:
8. These 3 pheno-lead sprays should be preceded by a petal fall spray of sulfur and lead arsenate or sulfur-lead arsenate-Fermate and the first cover may be started with the same materials but a change to the pheno-lead is suggested in time to precede heavy hatching:
9. No lime is suggested for sprays preceding pheno-lead applications:
10. In many orchards, it will be desirable to follow with an arsenical injury corrective together with additional lead arsenate about 50 days after petal-fall of Stayman. A ½-2-100 Bordeaux mixture or zinc sulfate-lime may be used safely on dry foliage as a corrective. Later sprays will be required where control of first brood is inadequate. Where fruits are grown for processors, pheno-lead may be used in second brood sprays. However, interference with normal color development and the chalky gray residue may make it undesirable for second brood sprays on fruits produced for fresh fruit markets:
11. Phenothiazine is relatively safe when compared to many poisons, but the effects on those who spray with it for long periods of time are not well known. Individuals are known to vary in susceptibility to skin burn. Painful sores can result if the hands are rubbed in gloves soaked with phenothiazine spray in a single day of spraying. It is suggested that a protective paste be used over exposed skin surfaces and that ointments be on hand to relieve skin burn after exposure. The writer, after spraying in the drip from pheno-lead for periods totalling 40 hours during the season and making no effort to change from saturated clothing for some time after each spray application experienced no burning from pheno-lead in 1944 although conditioned phenothiazine had given skin burn in 1942:
12. The usual precautions against inhaling dry spray powders should be observed in handling pheno-lead.

VIRGINIA

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Codling moth injury in 1944 was more severe in northern Virginia than in any previous season for the past 25 years.

Most of the orchard tests were a continuation of last year's experiments which were intended primarily to observe the influence of various spreaders and stickers on lead arsenate in control of the codling moth. Tests were also continued with various concentrations of lime, zinc sulfate and lime, and copper sulfate and lime as correctives for arsenical injury. The results as shown in table 1 indicated that crude soybean oil (plot 30) reduced the percentage of injured fruit, i.e., worms and stings, more than any other sticker or spreader used with lead arsenate. Several of the commercial products added little or nothing to the efficiency of lead arsenate. Among the materials which appeared to lower the toxicity of lead arsenate were DN-111 in plot 21, lime 10 pounds in plot 25, Mixol in plot 34, and Watkins Dip in plot 36. In several others the percentage of wormy fruit was somewhat higher than in the plots which received lead arsenate alone or in combination with the usual amounts of lime as in plots 3, 22, 23, and 24. Arsenical injury was severe in plot 3 only, all correctives gave satisfactory control of this phenomenon.

DDT as used in plots 1, 2, 42, and 43 greatly reduced the number of "stings" and consequently the percentage of fruit showing codling moth injuries. In plots 1 and 2 the percentage of wormy apples was slightly higher than in several of the best lead arsenate plots. A higher concentration of DDT (1 pound--100 gallons) as used in plots 42 and 43 kept the fruit relatively free from live worms until late in August when live entries appeared in plot 43 which had not been sprayed after the sixth cover on July 24. Plot 42 received an additional cover spray on August 8 which gave better protection against live entries for the remainder of the season.

No spray injury was noted on any of the trees in the DDT plots. Varieties included Stayman-Winesap, Arkansas, and Delicious. Bordeaux mixture 2-4-100 formula was used in the sixth cover in plots 2, 42 and 43; and in the third cover in plot 42, to which lead arsenate was also added.

When examined in early September mites had increased greatly on the foliage of all trees which received the DDT sprays, averaging 2,551 mites per 100 leaves compared to 2 per 100 leaves on trees which received the lead arsenate sprays.

In the above tests the "Gesarol" DDT preparations were obtained

from Geigy Company and 25 percent DDT from DuPont Company. The products mixed readily with water.

Table I. Results of orchard tests, Winchester, Va.

Note: Lead arsenate 3 pounds in calyx spray.

Plot No.	Cover Sprays	Materials per 100 gallons (# = lb.)	Percent Wormy	Percent Injured
1	1-7	Gesarol (A-20) 2#	7.1	15.7
2	1-2 3-7 3-5,7	Lead 3#, lime 2# Gesarol (A-20) 2# Gesarol oil (SH-5) 1 gal.	5.3	14.0
3	1-7	Lead 3#	2.6	34.4
4	1-2 3-7	Lead 3#, lime 2# Black Leaf-155 3#, oil 1 pt.	13.0	33.9
5	1-3 3-7	Lead 3# Black Leaf-155 1/ 3#, oil 1 pt.	4.2	16.5
6	1-4 5-7	Lead 3# Lead 1 1/2#, Black Leaf-155 3#, oil 1 pt.	3.6	20.2
7	1-7 2-7	Lead 3# Bordeaux 1/4-1-100	2.6	18.6
8	1-7 2-7	Lead 3# Bordeaux 1/2-1-100	7.0	18.3
9	1-7 2-7	Lead 3# Bordeaux 1/2-2-100	5.1	26.9
10	1-7	Lead 3#, zinc-lime 1/4-1-100	4.8	32.0
11	1-7	Lead 3#, zinc-lime 1/2-1-100	7.9	30.7
12	1-7	Lead 3#, zinc-lime 1/4-2-100	2.9	22.6
13	1-7	Lead 3#, zinc-lime 1/2-2-100	1.7	31.5
14	1-7	Lead 3#, zinc oxide-lime 1/2-1-100	3.8	27.2
15	1-7	Lead 3#, lime 2#, $Al(OH)_3$ paste 3#	8.8	34.9
16	1-7	Lead 3#, lime 2#, Colloidal-77 6 oz.	6.7	33.1
17	1-7	Lead 3#, lime 2#, (Z-1) .33#	4.1	29.2
18	1-7	Lead 3#, lime 2#, Ortho Dry Spreader 1/2#	1.5	26.7
19	1-7	Lead 3#, lime 2#, Grasselli Spreader 1 oz.	5.0	32.9
20	1-7	Lead 3#, lime 2#, Soybean flour 1/2#	5.4	31.5
21	1-7	Lead 3#, DN-111 1 1/4#	10.0	29.3
22	1-7	Lead 3#, lime 2#	3.0	32.9
23	1-7	Lead 3#, lime 3#	2.2	26.9
24	1-7	Lead 3#, lime 5#	2.7	23.0
25	1-7	Lead 3#, lime 10#	12.4	44.1
26	1-7	Lead 2#, lime 2#	7.9	33.8
27	1-7	Lead 4#, lime 2#	2.5	16.5
28	1-7	Lead 3#, lime 2#, Kerosene-soap 1/2 gal.	4.2	33.8
29	1-7	Lead 3#, lime 2#, Kerosene 2 qt. Crude soybean phosphatides 8 oz.	3.0	21.9

1/Mississippi Bentonite

Table I. (Continued)

Plot No.	Cover Sprays	Materials per 100 gallons (# = lb.)	Percent Wormy	Percent Injured
30	1-7	Lead 3#, lime 2#, crude soybean oil 1 qt.	1.7	15.1
31	1-7	Lead 3#, lime 2#, Spraylastic 1 qt.	3.3	22.5
32	1-7	Lead 3#, lime 2#, Orthex 1 pt.	1.7	20.6
33	1-7	Lead 3#, lime 2#, Orthex 1 qt.	5.3	24.8
34	1-7	Lead 3#, lime 2#, Mixol 1 pt.	9.3	36.5
35	1-7	Lead 3#, lime 2#, fish oil 1 qt.	5.1	29.4
36	1-7	Lead 3#, lime 2#, Watkins Dip 2 qts.	10.1	53.3
37	1-7	Lead 3#, lime 2#, light oil 1 qt.	2.8	21.2
38	1-7	Lead 3#, lime 2#, light-medium oil 1 qt.	5.6	28.7
39	1-7	Lead 3#, lime 2#, Nufilm 1 pt.	6.0	27.9
40	1-7	Lead 3#, lime 2#, Nufilm 1 qt.	5.5	23.9
41	1-7	Lead 3#, lime 2#, Triton (B-1956) 2 oz.	2.5	16.0
42	1-3 3-7	Lead 3#, lime 2# 25% DDT 4#	1.7	10.1
43	1-3 4-6	Lead 3#, lime 2# 25% DDT 4#	4.2	14.1
		Checks, unsprayed	76.9	83.1

Exploratory work on the removal of DDT residue as shown in Table II indicated that current methods of spray residue removal were not efficient means for the removal of DDT residue.

Table II. DDT residue and results of treatment for its removal from Stayman-Winesap apples picked from Plot 42 on October 6, 1944.

Treatment for removal	Temp. of wash	DDT residue gr./lb.
Not treated		.042
Washed 45 seconds in HCL 1.3%	71° F.	.037
Washed 45 seconds in Sodium silicate 75 lb. and soap 1 lb. per 100 gallons........................	71° F.	.027
Washed 45 seconds in Trisodium phosphate 10 lb. per 100 gallons	62° F.	.034
Brushed, Trescott machine		.041

VIRGINIA (Continued)

A. M. Woodside, Field Laboratory, Virginia Agricultural Experiment Station, Staunton.

The carry-over of codling moths was very heavy in those orchards which had borne a crop in 1943. Emergence of spring-brood moths began about a week earlier than the usual time, and the emergence reached an early peak. The temperatures were considerably above normal during the spring-brood flight, but there were frequent rains, which aided in holding the infestation down. Infestation was much lower in orchards which had a crop failure in 1943. Emergence of first-brood moths remained high until it merged with the second-brood flight, which started about the middle of August. Precipitation during the ten-week period of heavy moth flight all came in a few heavy rains, thus interfering little with the egg-laying. Infestation increased rapidly during this period, as most of the orchards were on a non-wash schedule, and nicotine could not be obtained for emergency sprays. The prospective carry-over is the heaviest for many years.

The predacious beetle, Tenebroides corticalis Melsh., became more common under bands late in the season than it has been for several years; but it had little, if any effect on the infestation this season. It may have had some slight effect on the number of larvae entering hibernation in some orchards.

WASHINGTON

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I. SEASONAL CONDITIONS AND STATUS OF CODLING MOTH INFESTATION DURING 1944

Prevailing temperatures were favorable to the codling moth for the 1944 season. Minimum monthly temperatures were as follows: November 1943, 24°; December, 17°; January, 1944, 8°; February, 18°; March, 22°; April, 31°; May, 41°. Maximum temperatures for period of moth activity for 1944 were, May, 92°; June 94°; July 104°; August, 94°; with eight days with a maximum above 90°; September 97°; with eight days (4th to 11th, inclusive) having a maximum temperature above 91°. Rainfall reported in inches for the period April 1 to September 30th was as follows:

April, 0.93; May 0.31; June, 1.42; July, 0.09; August, 0.52; September 0.61.

Bait traps began catching moths on May 3rd, indicating this date for the earliest emergence of the spring brood of moths. Prevailing temperatures during the month of May were generally favorable for emergence and moth activity. The daily peak catch of moths occurred on May 20th but the period, May 25 to May 30, showed the highest sustained catch for the spring brood of moths. First larval entry occurred about May 29 which was only a day or so earlier than the two preceding seasons. The favorable conditions which prevailed from June to September resulted in a severe attack by the codling moth with late larval entry continuing well into the early harvest period.

Despite the handicaps of extremely windy conditions and inexperienced help during the early cover sprays, growers generally produced a commercially clean crop of fruit as evidenced by a packed crop of 14,400,000 boxes estimated for the Wenatchee-Okanogan district.

II. RESULTS OF CONTROL EXPERIMENTS

(a) Experimental set-up.

Plots consisted of two trees in a block of top worked delicious variety without replication.

(b) The inclusion of additional materials in the lead arsenate or cryolite plots appeared to reduce the efficiency of codling moth control for all plots due to the severe infestation and continued attack of late season larvae.

Table I. Control by Insecticides

Plot No.	Plot Treatments and Materials per 100 Gallons
1	DDT 1 1/2 lb. 1/ (2 gal. kerosene), 3 sprays, 5/26, 6/5, 6/28.
2	DDT 1 1/2 lb. (2 gal. kerosene), 6 sprays, 5/26, 6/5, 6/28, 7/24, 8/3, 8/15.
3	Same as L. A. check treatment 1st brood; DDT 1 1/2 lb. (2 gals. Kerosene), 3 sprays, 7/24, 8/3, 8/15.
4	Lead arsenate 3 lb., "DN-111" 2/ 5 oz., 7 sprays 3/
9	Same as L. A. check treatment except "DN-111" 1 oz. added to all sprays.
12	L. A. 3 lb., petroleum oil (light) 1 qt., 1st & 5th covers--3 qt., 2nd, 3rd, 4th, 6th and 7th covers.
13	Same as L. A. check 2 covers; L. A. 3 lb., kerosene 2 gal., 5 covers.

Table I. (Continued)

Plot No.	Plot Treatments and Materials per 100 gallons
15	Same as L. A. check 3 covers; L. A. 3 lb., 314R 4/ (rotenone extractives) 1 1/2 pt. 4 covers.
16	Same as L. A. check 1st brood; L. A. 3 lb., "DN-111" 5 oz., 3 sprays.
L.A. Check	Lead Arsenate 3 lb., light petroleum oil 1 qt., 1st, 5th, and 7th covers--2 qt., 2nd , 3rd, 4th, and 6th covers.
17	DDT 15 oz. (5 qt. kerosene), 3 covers, 5/26, 6/5, 6/28.
18	DDT 16 oz. (5 qt. kerosene), 6 covers, 5/26, 6/5, 6/28, 7/25, 8/4, 8/16.
19	Same as cryolite check 1st brood; DDT 15 oz. (5 qt. kerosene), 3 sprays, 7/25, 8/4, 8/16.
20	Cryolite 3 lb., "DN-111" 5 oz., 7 sprays.
25	Same as cryolite check except 1 oz. "DN-111" added to all sprays.
28	Cryolite 3 lb., light petroleum oil 1 qt., 1st and 5th covers,--3 qt., 2nd, 3rd, 4th, 6th, and 7th covers.
29	Same as cryolite check 3 covers; cryolite 3 lb., 314R (rotenone extractives) 1 1/2 pt., last 4 covers.
30	Same as cryolite check 3 covers; AK-20 5/ (DDT 20% in pyrophyllite) 2 lb., 4 covers.
31	Same as cryolite check 2 covers; cryolite 3 lb., kerosene 2 gal., 5 covers.
32	Same as cryolite check except Xanthone 6/ (Genicide) 2 lb., casein ammonia-kerosene 1 qt., used in last 2 covers, 8/4 and 8/16.
33	Same as cryolite check 1st brood; cryolite 3 lb., "DN-111" 5 oz., 3 sprays.
Cryolite Check	Cryolite 3 lb., light petroleum oil 1 qt., 1st, 5th, and 7th covers--2 qt., 2nd, 3rd, 4th, and 6th covers.

1/ DDT was secured from Geigy Company as a DDT concentrate. This material was added to a drum of kerosene at the rate of 12 ounces DDT per gallon kerosene and sufficient B-1956 added to emulsify the oil.

2/ DN-111, a commercial product of Dow Chemical Company, 20 percent dicyclohexylamine salt of DNOCHP.

Table I: Footnotes (Continued)

3/ Cover spray dates for all sprays unless otherwise noted were four first brood sprays applied 5/26, 6/5, 6/15, 6/28; three second brood sprays 7/24-25, 8/3-4, 8/15-16.

4/ 314-R, a rotenone extractive by American Cyanamid Company.

5/ AK-20, DDT 20 percent in Pyrophyllite; Geigy Company.

6/ Xanthone (Genicide) General Chemical Company.

Efficiency of control was determined by examination of 200 apples per tree taken uniformly from all boxes harvested. The percentage of wormy, stung and clean fruit based on the 200 fruit sample per tree are set forth as mean percentages in Table II. Extremely close correlation in control resulted on the two trees comprising each treatment. In no case did the variation from the mean exceed 10 percent. Four plots, 1, 16, 17 and 28, showed a variation in excess of 5 percent in number of wormy fruits or in number of clean fruits. The remainder of the plots showed a variation from the mean of from a fraction of one percent to three percent.

Table II. Percentage injured and clean harvested fruit.

Plot Number	Percent Wormy	Percent Stung Only	Percent Clean
1	16	9	75
2	0.7	6.2	93
3	5.5	25.5	69
4	70	13.7	16.2
9	47.5	32.2	20.2
12	21.5	24.5	54
13	43	24	33
15	32.2	25.5	42.2
16	59	14.5	26.5
Lead Arsenate Check	36	29.2	34.7
17	21.2	15.5	63.2
18	1	12.5	86.5
19	14	28.2	57.7
20	52.2	24.7	23
25	45	30	25
28	15.2	30.2	54.5
29	17.7	31	51.2
30	6.2	20.5	73.2
31	21	29.5	49.5
32	15	22.7	62.2
33	30	28.5	41.5
Cryolite Check	13.5	33.7	52.7

DDT employed for the control of codling moth as set forth in the preceding table appeared to influence the abundance of Pacific mites.. This was particularly true when first brood sprays only were used or when no oil was employed in the program. Counts of mites on the DDT sprayed trees showed several times the number of mites present as compared to trees sprayed with a different material. Woolly apple aphids also appeared to be more numerous on the DDT treated trees.

(d) Spray Residue.

The residue remaining on the fruit at harvest was determined by chemical analysis. The DDT determinations have not yet been completed and are necessarily omitted in this report. Table III sets forth the residue of lead or fluorine as determined for the remainder of the treatments.

Table III. Residue Load at Harvest in Grain per Pound of Fruit 1/

Plot Number	Lead	Fluorine
4	.305	
9	.511	
12	.462	
13	.404	
15	.250	
16	.366	
Lead Arsenate Check	.377	
20		.196
25		.257
28		.320
29		.220
31		.270
32		.194
33		.290
Cryolite Check		.177

1/ Results presented are the average results of duplicate analysis on unwashed fruit.

SPRAY INJURY:

Periodic examinations were made for all spray treatments to determine any injury to fruit or foliage. No direct injury to the fruit was observed. A secondary effect was apparent on those plots in which the foliage was injured by the sprays. This was manifested in lack of color and size of the fruit accompanied by an abnormally heavy pre-harvest drop of fruit.

DDT - kerosene treatments resulted in a characteristic type of injury which became apparent on plots 1 and 2 within ten days after the first cover spray. This particular injury first appeared as a faint mottled chlorosis which progressed after subsequent sprays until the leaves showed necrotic areas either as shot holes or large irregular areas covering 1/4 to 3/4 of the entire leaf blade. The order of severity was in proportion to the number of applications and the concentration of DDT. Plot 30 (DDT pyrophyllite) did not exhibit the type of injury encountered in the DDT kerosene plots. Late in the season, after severe mite damage had occurred to the foliage, a type of injury developed but it is not certain whether due to DDT or mites.

The only other injury of any consequence was found on the DN-111-oil plots 9 and 25 and on the DN-111 second brood, plots 16 and 33. It is of interest to note that the use of DN-111 with either lead arsenate or cryolite throughout the season, plots 4 and 20 gave no important injury whereas these same treatments, plots 16 and 33 applied after considerable foliage injury by mites had occurred, resulted in considerable injury.

WISCONSIN

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A One-spray Treatment of DDT as a Control for Second Brood Codling Moth in Wisconsin

The codling moth is a constant hazard to the production of good fruit but most of the injuries are caused by the second brood which works late in the season, particularly during August and September. Even in well cared for apple orchards the infestation often reaches 25 percent.

Late summer sprays to check this infestation are objectionable, from the visible as well as the actual residue which is often present at picking time. To attempt to overcome these objections and to produce cleaner fruit DDT as a one spray treatment was tried this past season on a limited scale.

The orchard chosen had received the regular treatment of four cover sprays of lead arsenate, the last being applied July 22. The DDT used was technically pure GNB DDT made by the Geigy Company. In order to secure a good water suspension the DDT was thoroughly mixed with a neutral sodium oleate at the following dilutions:

DDT .... 91 grams

Neutral sodium oleate .... 40 grams

Water .... 25 gallons

This was enough material to treat eight trees; two Wealthy, three McIntosh, one Red Starking Delicious, one Golden Delicious, and one Salome. Counts on the last two were not recorded. Neighboring like varieties were used as controls but all trees received the same lead arsenate lime sulfur sprays. The DDT was applied August 5, probably a few days early to be most effective. However, it was applied early with the anticipation that its effectiveness would continue for six weeks. Second brood flight of codling moths as recorded by nine bait traps is as follows:

Date	No. Moths	Date	No. Moths	Date	No. Moths
July 23	3	August 3	8	August 14	9
24	0	4	20	15	3
25	4	5	10	16	1
26	3	6	3	17	1
27	11	7	8	18	2
28	4	8	6	19	3
29	7	9	10	20	2
30	0	10	34	21	4
31	1	11	22	22	7
August 1	2	12	5	23	1
2	4	13	17		

Picking and counting began August 25th on the Wealthy variety and was finished October 12th with the Red Starking. All the apples of each tree were counted including the drops. Insofar as it was possible to do so, only second brood injuries were tabulated.

The results are given in the following table.

Table I. Results of one Spray Treatment 1/ of DDT to Control Second Brood Codling Moth, Madison, Wisconsin, 1944.

Treatment	Variety	Dates Picked	Total Apples	Number of Apples Stung	Wormy	Free	Percent Injured
Control	Wealthy	Aug. 25,26, and 30 Sept. 5,8,15.	1721	73	2/--	1648	4.3
DDT	Wealthy	Do	2528	54	--	2474	2.1
Control	McIntosh	Sept. 18,21 and 26.	514	75	15	424	17.5
DDT	McIntosh	Do	1922	112	61	1749	9.C
Control	Starking Delicious	Oct. 4, 12	834	74	22	738	11.5
DDT	Do	Do	1007	91	25	891	11.5

1/ Trees had previously received a four-cover lead arsenate treatment. Counts of wormy and stung fruit included only 2nd brood worms as far as it was possible to determine.

2/ Stung and wormy fruits were not kept separate for the wealthy variety, but most of the injuries were stings.

Conclusion

At the strength used, .8 pound to 100 gallons water, DDT was not very effective as a one-spray treatment for second brood codling moth. Toward the end of the picking season as noted by the counts of the red starking variety the DDT had apparently entirely weathered off as there was no differences between sprayed and unsprayed apples. Many of the worm entrances to the apples were very recent indicating a late hatch of the moth.

CANADA

Jas. Marshall, Dominion Entomological Laboratory, Vernon, British Columbia.

Codling moth investigations for 1944 were carried out in 14 different orchards in British Columbia. To give details of the various experiments would necessitate a lengthy report since each would involve a separate description of experimental procedure and other data. Accordingly, the investigations are summarized. Conclusions reached by those "on the ground" serve as a basis for future work and for spray

recommendations in this province. They are included in case they might be informative to investigators in other areas.

The district in which the experiments were carried out is semi-arid. Irrigation is necessary. Every year there is a partial second generation of codling moth larvae and some years a partial third generation. The season of 1944 was warm during flight of the codling moth and weather conditions are presumed to have been favorable for establishment of the insect. There was little winter mortality.

I. FIELD INVESTIGATIONS

Trunk Sprays:

Investigation of tree trunk sprays has been under way since 1941 in six different districts. It has been concluded that under certain circumstances it is advisable to apply a trunk spray, not that in itself it is capable of controlling codling moth, but because it is valuable as a supplement to the ordinary summer spray procedure. The circumstances under which it will be recommended are: First, an infestation of 10 percent or more; second, the presence of overwintering codling moth larvae on the trees. In certain orchards there seems to be a tendency for larvae to overwinter in the soil, where they are not likely to be reached by a trunk spray application.

A small amount of extra equipment is necessary to adapt the ordinary portable sprayer for the application of a trunk spray. Ordinary spray guns are lengthened about 18 inches by brazing 1/4 inch pipe to the heads. Forty-five degree elbows are screwed to these extensions and to the elbows are attached nozzles bearing discs of 4/64 inch aperture. Y's inserted in the pressure lines make it possible to use four lines of hose on a single portable machine. Swivels interposed between guns and hoses ensure more efficient application.

The preferred spray mixture consists of distillate (furnace or Diesel) oil of approximately 40 S.S.U. Vis. 100°F. 15 gallons; dinitro-o-cresol or dinitrocyclohexylphenol 3 lb.; sodium lauryl sulfate or VATSOL K 2, 5 pounds; water to make 100 gallons. If the dinitro compound is used at 40 percent concentration, the remainder being an insoluble inert e.g. DINITRO DRY, only half the amount sodium lauryl sulfate or VATSOL K is indicated.

Approximately 2 gallons of spray are required for a 30 year old tree. The spray is applied at about 150 pounds pressure to trunks and scaffold limbs, preferably directed upwards with the nozzle held not more than 6 inches from the sprayed surface. Good agitation is essential since the oil emulsion must be rather unstable in order to give maximum penetration of the codling moth cocoon. Properly applied, the trunk spray has killed up to 80 percent of the larvae overwintering on the sprayed parts of the tree. At harvest, reduction in infestation has ranged up to 50 percent. Cost of a trunk spray including labor, should be less than 1 cent per box of fruit. The application is made in spring between the date when the sprayer can first travel in the orchard and the early pre-pink period of bud development.

Trunk Sprays--Investigation of Tree Injury:

To determine the effect of various types of oils and oil-dinitro solutions, as well as emulsions of both, on the trunks and scaffold limbs of apple trees, investigations were carried out for the third successive year on two acres of McIntosh and Jonathan at the East Kelowna Substation of the Dominion Experimental Farms System.

With repeated application, evidence is accumulating that very light oils (32-33 S.S.U. Vis. 100°F.) are more toxic than oils of 40 S.S.U. Vis. or higher. In turn, oils of 40 S.S.U. Vis. have been more injurious than ordinary dormant oil. Addition of dinitrocresol to oil apparently increases injury to some extent. Only slight injury has occurred from 50 percent distillate oil (38-40 S.S.U.Vis. 100°F.) emulsion containing 2 percent dinitrocresol in oil solution. No injury has followed the use of 25 percent distillate emulsion containing dinitrocresol.

Summer Sprays:

In 1944 experimental work was carried out on about 7 acres in two orchards at East Kelowna. The work is summarized thus:

a) Fixed nicotine: For the second year, a tank-mixed fixed nicotine mixture composed of nicotine sulfate 9.6 ounces average (8 fluid ounces), Mississippi bentonite 4 pounds, summer oil 0.5 gallon, monethanolamine oleate 0.25 pound gave codling moth control equivalent to the currently recommended lead arsenate-casein-lime and cryolite-casein-lime. Chemical analyses have shown that it gives a reasonably heavy nicotine deposit. Growers who used this mixture at Penticton, Kelowna and Vernon were satisfied. Mississippi bentonite-fixed nicotine mixture will be recommended for use in 1945. It was first studied by the U. S. Bureau of Entomology.

b) Tall Oil: A byproduct of the paper industry, tall oil has been found satisfactory as a substitute for oleic acid in making summer oil emulsions. It costs only half as much as oleic acid. Sometimes growers when using summer oil, either do not emulsify it or use casein-lime for the purpose. The result is an unsightly, spotted deposit of the powdered solid compoent that prevents even coloration of the fruit, and that may be hard to remove. The use of an emulsifier such as oleic acid-monoethanolamine or tall oil-monoethanolamine brings about a heavier deposit but one which, because it is more uniform, is less obvious.

c) <u>Slightly Refined and Non-Refined Petroleums</u>: Repeated experiments have shown that under conditions obtaining in the interior of British Columbia, oils of 75 S.S.U. Viscosity at 100°F. are satisfactory for use with fixed nicotine at a concentration of 0.5 percent. Practically no highly refined oil has been sold in the province in recent years.

Since 1942, experiments have included oils of still lower unsulphonated residue--only 4 - 5 percent. Each year fixed nicotine mixtures made with such oils have given codling moth control as satisfactory as mixtures containing ordinary summer oil. Chemical analyses during 1944 suggest that the nicotine deposit may be higher with these oils than with highly refined products.

The generally accepted view of summer oils would bar these relatively crude petroleums from consideration as summer sprays because of the great importance that has been attached to a high unsulphonated residue as an indicator of safety to foliage and fruit. Nevertheless five applications of 4 percent U.R. oils each year have caused no more foliage injury or fruit injury than a similar number of applications of highly refined oil. Indeed, in 1944 when all oils were applied a week after the application of sulfur, distinctly less oil-sulfur injury followed the use of 4 percent U.R. oil than ordinary summer oil. These low-grade oils cost only one fifth as much as highly refined summer oil. It is clear that they merit further study.

d) <u>Phenothiazine</u>: Work on phenothiazine for codling moth control was begun in the Okanagan Valley in 1937 and has continued to 1944. It has clearly been established that this compound, when wetted by oil, is, under arid or semi-arid conditions, about five times as effective, pound for pound, as lead arsenate, cryolite or fixed nicotine. To be most toxic it must be micronized and it must be applied with a small amount of light petroleum oil such as stove oil. Since phenothiazine has a tendency to cause a deepening of the green color of apples, it may be used to best advantage in the early cover sprays--perhaps the first three.

e) <u>DDT</u>: DDT obtained from Geigy, was applied at 0.5 pounds per 100 gallons (lmp) dissolved in acetone then dispersed with sodium lauryl sulfate 2 ounces per 100 gallons (Imp). Limited field experiments in 1944 have suggested that so used, it is of about the same order of effectiveness as micronized phenothiazine applied with stove oil i.e. at least five times as effective as lead arsenate. It caused no evident injury to foliage or fruit but like phenothiazine it apparently caused pronounced increase in European red mite infestation. Combined application with DN-111 1 pound per 100 gallons (Imp.) appeared to offset increase in mite population.

Moth Sprays:

Experiments were continued for the fourth successive year with moth sprays. They have not yet proved as profitable as those with tree trunk sprays. At East Kelowna derris added to each of the ordinary cover sprays seemed to have little value. Nicotine sulfate at the rate of 1/4 pint per 100 gallons added to the ordinary cover sprays, however, resulted in definitely improved codling moth control. It is not clear if the improvement stemmed entirely from the destruction of the adult insects or if there might have been increased mortality of the newly hatched larvae as well. Ammonium dinitrocresolate 4 ounces per 100 gallons added to the regular cover sprays gave little apparent improvement in codling moth control but for the fourth successive year caused an increase in size of McIntosh apples of approximately 20 percent. Since only in unusually humid seasons have dinitrocresol derivatives been noticeably effective against codling moth adults, it is doubtful if their use is indicated for this purpose. Their unexpected effect on McIntosh apples is a matter for investigation by horticulturists.

Factors Influencing Severity of Codling Moth Attack:

Twenty-one years ago Isely and Ackerman came to the conclusion the most important factor leading to severe codling moth attack was a long period of warm nights during flight of moths of the overwintered generation. With that in mind hygrothermographs were set up in two orchards near Kelowna, in one of which codling moth control is a simple matter and in the other a most difficult matter. The orchards are about equidistant from Okanagan lake. They are similar as to elevation, soil type, age of trees, cover crop and varieties. In one orchard air drainage is poor, in the other, good.

Although maximum daily temperatures were similar in the two orchards, the hourly temperatures 7 p.m. to 11 p.m. were on most nights considerably higher in the orchard with good air drainage and heavy codling moth attack. During codling moth flight periods, temperatures averaged approximately 3 degrees higher in that orchard. On several occasions, the mean temperature during the 7-11 p.m. period was nearly 9 degrees higher. According to Isely and Ackerman such a temperature difference is sufficient to account for a four-fold increase in oviposition. Relative humidity during the 7-11 p.m. period averaged approximately 10 percent less in the orchard subject to heavy codling moth attack. It seems that purely from the standpoint of codling moth control, the most suitable location for an orchard in the Okanagan Valley is a frost pocket and the least suitable, a western exposure with good air drainage.

II. LABORATORY INVESTIGATIONS

Larvicides:

Against newly hatched codling moth larvae, three new types of calcium arsenate, the acridine and nicotine salts of dinitrocresol, nicotine cuprocyanide, nicotine Reineckate, THANITE (fenchyl thiocyanoacetate,) micronized phenothiazine and DDT, were compared on laboratory sprayed fruits.

When used without oil, the materials that allowed fewer entries than lead arsenate 4 pounds per 100 gallons, were, in order of decreasing effectiveness, Phenothiazine 1 pound, DDT 1 pound, nicotine Reineckate 1 pound, nicotine cuprocyanide 1 pound.

The calcium arsenates, the nicotine salt of dinitrocresol, the acridine salt of dinitrocresol and THANITE were not sufficiently effective.

When used with stove oil 0.5 gallons, DDT 0.5 pounds, allowed no entries, phenothiazine 0.5 pounds allowed 8.5 percent entries and lead arsenate 4 pounds allowed 48 percent entries. When sprays were applied 10 days prior to larval attack, the DDT-stove oil mixture still allowed no entries. Phenothiazine-stove oil however, lost its effectiveness to a considerable extent (48 percent entries). Lead arsenate-stove oil allowed 68 percent worm entries after 10 days.

Other experiments involved examination of the effectiveness of DDT and phenothiazine as dusts. DDT was found highly toxic to larvae that crawled even for five minutes over deposits equivalent to those encountered in the field. It was far more toxic in this way than lead arsenate. After three weeks, the DDT deposit had almost unimpaired toxicity but phenothiazine apparently became almost innocuous in the same period.

Behavior of Newly Hatched Codling Moth Larvae:

A break in the skin of an apple either by a very fine needle-prick or by an attempted entry of a codling moth larva was found to render the apple more susceptible to successful entry by the codling moth larva than an apple with unbroken skin. When the skin of the fruit was unbroken, the codling moth larva had a distinct preference for entering via stem or calyx basin, but if there was even a minute puncture on the cheek of the fruit, the preference was reversed, over 50 percent of the larvae locating and entering via the puncture.

Presence of a repellent residue such as lead arsenate apparently enhanced the attractiveness of a puncture or break in the skin of the apple.

When as in the case of heavy infestation, several larvae in succession attack an apple, the likelihood of successful entry through an insecticide deposit is evidently more than proportionately increased. The early arrivals in spite of dying before making an entry, frequently do manage to break the skin so that later larvae which are very likely to discover the break in the skin, succeed in exploiting the ready-made site of entry. This work evidently provides one explanation for the increasing difficulty of codling moth control as heavy infestations become more common. No doubt an even more important factor is the development of a strain of codling moth resistant to the generally used stomach insecticide such as lead arsenate, cryolite, or fixed nicotine. This point has been demonstrated by investigators in the United States.

Action of Inert Dusts on Codling Moth Larvae:

Some powdered substances, presumed to be inert, have been shown to be toxic, when certain types of insects crawl over them. The action is one of desiccation following abrasion, i.e. the waxy layer on the body of the insect is rubbed off at point of contact with the dust and body water is rapidly lost by evaporation. Experiments with substances such as finely divided silicon carbide have so far not shown promise as far as codling moth control is concerned.

CANADA (Continued)

W. G. Garlick and W. L. Putman, Dominion Entomological Laboratory, Vineland Station, Ontario.

I. Seasonal Conditions and Status of Codling Moth Infestations during 1944.

In those areas of Ontario subject to serious codling moth injury the infestation was generally worse than in 1943, with considerable late injury. There were notable exceptions, however, in quite a number of orchards where very little late injury occurred and spraying consequently gave good results. The only explanation we can suggest is erratic rainfall, the showers being often extremely localized. In a local orchard spring moths appeared about a week earlier than in 1943 and were much more numerous. First generation larvae matured a few days earlier and first generation moths were earlier, both first and peak emergence. However, after the end of August hardly any larvae matured as compared with large numbers in 1943.

II. Studies on Codling Moth Biology or Behavior

Biennial Habit: Out of a total of 4049 larvae that survived the winter in pasteboard in an open insectary, 25 larvae (about 0.6 percent) did not transform this season and are expected to give rise to moths in 1945. These non-transforming larvae were taken in band collections from August 12 to October 13, 1943.

Correlation of Time of Maturing of Diapause Larvae with Time of Transformation the Following Spring: The observations made this season are in agreement with those given in this report for 1943. The earliest and latest maturing diapause larvae gave rise to the earliest moths this spring. Those maturing during midseason produced moths later this spring.

III. Results of Control Experiments

The materials used in 1944 tests were as follows:

Gesarol A 20 - DDT 20% with wetting agents. Geigy Co., New York.

Gesarol AK 20 - DDT 20% without wetting agents.

Gesarol A - DDT 5%, Geigy Co., New York.

DDT-talc - DDT (Geigy's GNB-A-DDT) 10%, talc 87%, orvus 3%, ground twice, under our direction, in hammer mill in a local insecticide plant.

DDT - Except as the Gesarols, all DDT was manufactured by Dodge & Olcott Co., New York. M.P. 104-105° C.; para-para-isomer 96%.

Coposil - Copper as metal 20%; zinc 4%. Active ingredient copper ammonium silicate. Manufactured by California Spray-Chemical Corp., Elizabeth, N. J., sold by Niagara Brand Co., Burlington, Ontario.

Bartlett's Standard Wettable Sulphur - 94% micronized sulphur. N. M. Bartlett Spray Works, Beamsville, Ontario.

Imperial Markol HX oil - Viscosity S.S.U. 75-85; unsulphonated residue 96%. Imperial Oil Ltd., Leaside, Ontario.

Orchard Tests

At Vineland Station four covers were applied on June 13, 26, and July 11 and 22 on the following plots: Plot 1: DDT 1 pound per 100 Imperial gallons in all 4 covers; COCS (copper 26.5%) 1 7/8 pounds and lime 3 3/4 in first and second covers. Plot 2: Same as plot 1, but with Markol HX oil (Visc. 75-85, Uns. Res. 96%) at 1, 1/2, 1/2% in 2nd to 4th respectively. Plot 3: Lead arsenate 3 3/4 pounds in 1st to 3rd and 2 1/2 pounds in 4th; lime at twice these amounts; COCS 1 7/8 pounds in 1st and 2nd; Markol HX oil 1% in 2nd and 3rd, 1/2% in 4th.

Plot 4: Check; no insecticides applied. The DDT was generally used in the same form as in the corresponding spray at the Queenston orchard described later, but owing to extreme shortage of materials it was sometimes necessary to eke out the supply with small quantities of other DDT mixtures. Results from five young McIntosh trees in each plot (drops included) are given below:

Plot	Total Apples	Percent Clean	Percent Deep	Percent Stings
1	4085	73.4	21.8	4.8
2	5635	90.5	5.9	3.6
3	4565	81.3	10.3	8.4
4	6680	10.6	81.6	1.8

Effect on Trees - After the first application of DDT plus oil injury began to show up on the leaves. For this reason the oil was reduced to 1/2 percent in subsequent covers. The injury, burning and killing of leaf tissue, increased slowly and became quite serious. No spray injury to fruit appeared in any plot. DDT without oil caused no injury to fruit or foliage.

Effect on other insects - A fairly heavy infestation of European red mite appeared in plot 1. Plot 2, owing to the oil, remained free until late in the season when the infestation appeared to spread from plot 1.

In a very heavily infested orchard at Queenston a block of 20 large Fameuse trees were given four covers of DDT, beginning June 8, at intervals of 12 and 14 days with the following materials per 100 Imperial gallons.

First cover - Gesarol A 20, 7 1/2 pounds (actual DDT 1 1/2 pounds), Wettable sulfur 10 pounds.

Second cover - DDT-talc 10 pounds (actual DDT 1 pound), Wettable sulfur 10 pounds.

Third cover - DDT-talc 10 pounds (actual DDT 1 pound).

Fourth cover - Gesarol AK 20, 5 pounds (actual DDT 1 pound) Orvus (30% sodium lauryl sulfate) 2 1/2 ounces.

Throughout the period of spraying the fruit remained remarkably clean. On July 26, nine days after the last DDT spray, and when the plot was still clean, a special application of 1 percent summer oil was necessary for European red mite. By August 12 codling moth larvae began to enter the

fruit and continued until at harvest two sampled trees bore an average of only 33.6 percent clean fruit (drops included). The surrounding orchard had only 7.4 percent clean fruit, failure of the water supply having prevented any late spraying.

It was evident that a coverage of DDT was highly effective against codling moth but its persistence, in the form used, was not very great.

Effect on Foliage and Fruit - About August 12 a certain amount of yellow leaf appeared followed by some premature leaf-fall, but this was not at all serious. Just what factors were responsible - DDT, oil or mite injury, is not known. Some cracking of the skins of the fruit was present at harvest but this may be characteristic of the variety under certain conditions.

Effect on other Insects - An outbreak of European red mite developed with remarkable rapidity on DDT sprayed trees between July 3 and 17. A spray of 1 percent summer oil on July 26 prevented any very serious injury.

The coccinellid Stethorus punctum Lec. was absent from the DDT plot but common on surrounding trees where it appeared to be the most important factor in controlling red mite.

White apple leafhopper was very much less abundant in the DDT plot. Woolly apple aphid was also less common but green apple aphids did not seem to be affected. Many syrphid larvae and a few chrysopid larvae were found in green apple aphid colonies.

Laboratory Tests

Methods

Apples, Wealthy and Jonathan, picked before maturity and kept in cold storage, were washed in 2 percent hydrochloric acid to remove spray residue. After the calyx and stem ends were waxed, the fruits were revolved individually in a precision sprayer. The exposure ensured the maximum deposit from all the mixtures tested, but as the spreading power, and consequently the run-off, of the different mixtures varied greatly, the actual deposit was not the same for each mixture. The results are, therefore, approximately comparable to orchard conditions insofar as relative retention of DDT on the fruit is concerned. As soon as the spray had dried on the fruit, 10 eggs hatching within the next 24 hours were pinned on each fruit and incubated at 77° F. and 75-85 percent relative humidity. Both stings and entries (living larvae) were recorded three days later, but the numbers of stings were so erratic that they have not been considered. The percentage establishment as given in the tables was calculated from the number of hatched eggs and number of entries, and is therefore inversely related to the degree of control.

Because of the difference in rate of establishment on unsprayed Jonathan and Wealthy apples only one variety was used in each phase of the investigations, and the data given under Part A, in which Wealthy was used, are not directly comparable with those in Parts B and C, obtained on Jonathan.

A. Comparison of DDT Mixtures

Wealthy apples used in all tests. Owing to the small number of replicates in some cases, small differences in results among mixtures are probably not significant. (See table 1.) It is believed that the data warrant the following conclusions:-

DDT in any form except as Gesarol A spray gave very much better control than acid lead arsenate, the majority of the DDT mixtures giving better results at 0.25 pounds than lead arsenate at 4 pounds.

DDT alone, ground in water with 3 percent by weight of Orvus in a ball mill for 20 hours gave consistently better results than any other mixture at all concentrations tested. At 1 pound per 100 gallons it gave nearly complete control.

The proprietary mixture Gesarol A Spray, containing 5 percent DDT was very ineffective even at 1 pound per 100 gallons giving only very slight reduction over the checks. That this was due in large part to excessive wetting agent was indicated in two tests where much better control was secured after most of the wetter had been removed by washing and decanting.

DDT in acetone solution, which gave a finely divided suspension on dilution in water, also gave very poor results, probably because of the wetting agent Triton X-100 which was necessary in the solution to prevent flocculation of the DDT when stirred in water. The solution contained 10 gm. of DDT and 10 cc. of Triton X-100 made up to 100 cc. with acetone.

DDT dissolved in Velsicol AR-60 with Triton X-100 as an emulsifier (10 gm. DDT, 10 cc. Triton X-100 made up to 100 cc. with Velsicol AR-60) was also ineffective, again as a result of heavy run-off owing to excess wetter. When a similar solution of DDT in Velsicol AR-60, but without Triton X-100, was emulsified with calcium caseinate (2 ounces per gallon of Velsicol) control was much higher.

As dry diluent for DDT pyrophyllite appeared to be superior to talc or frianite. All three mixtures contained 10 percent DDT, 3 percent Orvus and 87 percent diluent by weight and were thoroughly ground in the dry condition for 15 hours in a ball mill. It is possible that the amount of Orvus could be reduced to advantage, but it is difficult to disperse such a mixture in water because of the strong hydrofuge nature of DDT.

Table I. Comparison of Effect of DDT Mixtures on Newly Hatched Codling Moth Larvae.

Actual DDT in lb. per 100 Imp. Gal.	Form	No. of Tests1/	Total Larvae	Percentage Establishment In individual Tests	Percentage Establishment Average
1.0	Ground in water	4	367	0,0,2,1	0.8
1.0	Gesarol A Spray	1	92	51	51.0
1.0	DDT-talc-Orvus	2	186	6,9	7.5
1.0	DDT-pyrophyllite-Orvus	2	189	1,8	4.5
0.5	Ground in water	3	283	15,0,2	5.7
0.5	Gesarol A Spray	1	95	55	55.0
0.5	Gesarol A Spray Washed	1	96	19	19.0
0.5	DDT-talc-Orvus	1	88	18	18.0
0.25	Ground in water	6	517	8,13,1,4,4,5	5.8
0.25	DDT-talc-Orvus	6	539	34,25,5,17,20,22	20.5
0.25	DDT-pyrophyllite-Orvus	6	541	15,5,9,6,11,10	9.4
0.25	DDT-frianite-Orvus	5	448	27,10,30,22,23	22.4
0.25	Gesarol A Spray	3	283	47,57,56	53.3
0.25	Gesarol A Spray Washed	1	99	28	28.0
0.25	Acetone-Triton sol'n	4	328	49,52,30,42	43.2
0.25	Velsicol-Triton sol'n	4	304	33,24,52,51	40.0
0.25	Velsicol sol'n-calcium caseinate emulsion.	2	185	15,18	16.5
Lead Arsenate					
4		5	473	30,52,41,45,54	44.4
1		2	171	57,56	56.5
Checks	Not sprayed	9	854	66,74,75,73,68, 56,37,62,55	62.9

1/ 10 apples each.

B. Test of Gesarol A 20 Spray

The supply of Gesarol A 20 Spray (DDT 20%), received after the supply of Wealthy apples was exhausted, was tested separately on Jonathans. Results in table 2 indicate it is much less effective than water-ground DDT, at least partly because of the wetter it contains. Increasing the rate from 1 to 1.5 pounds per 100 gallons did not increase the kill.

Because of the difference in rate of establishment on unsprayed Jonathan and Wealthy apples only one variety was used in each phase of the investigations, and the data given under Part A, in which Wealthy was used, are not directly comparable with those in Parts B and C, obtained on Jonathan.

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Table II. Comparison of Effect of Gesarol A 20 Spray with Water-Ground DDT on Newly Hatched Codling Moth Larvae.

Actual DDT in lb. per 100 Imp. Gal.	Form	No. of Tests 1/	Total Larvae	Percentage Establishment: In individual Tests	Percentage Establishment: Average
0.25	Water ground	9	845	2,2,3,3,0,2,0,2,0	1.6
0.25	Gesarol A 20	5	469	16,35,16,16,23,0,0	21.2
1.00	Water ground	2	183	0,0	0.0
1.00	Gesarol A 20	5	471	14,11,10,6,20	12.2
1.50	Gesarol A 20	6	537	20,11,11,11,18,17	14.9

1/ 10 apples each.

C. Effect of Fungicides and Other Supplements with DDT

Table III. Influence of Fungicides and Other Supplements on the Effect of DDT on Newly Hatched Codling Moth Larvae on Jonathans.

Actual DDT in lb. per 100 Imp. Gal.	Supplement per 100 gal.	Number of Tests 1/	Total Larvae	Percentage Establishment: In individual Tests	Percentage Establishment: Average
0.25	None	9	845	2,2,3,3,0,2,0,2,0	1.6
0.25	Bordeaux 5-10-100	6	555	15,6,10,16,12,15	12.3
0.25	Coposil 2 lb.	6	583	0,0,1,1,0,0	0.3
0.25	Wettable sulfur 10 lb.	6	576	2,3,5,5,11,8	5.7
0.25	Hydrated lime 10 lb.	6	562	3,1,1,4,3,3	2.5
0.25	Marcol HX oil 1 gal. (emuls. with 2 oz. calcium caseinate)	6	569	2,2,1,1,0,0	1.0
0.25	Bordeaux 5-10-100 + Marcol HX oil 1 gal.	6	566	36,41,16,29,30,17	27.8
0.25	Coposil 2 lb. + Marcol HX oil 1 gal.	5	463	7,0,0,3,4	2.8
None	Marcol HX oil 1 gal.	6	549	46,56,49,64,49,48	52.0
None	None	7	639	83,77,92,66,83,71,86	79.7

1/ 10 apples each.

Results in table 3 were fairly consistent and justify the following conclusions:

Wettable sulfur, Coposil, and hydrated lime have no appreciable effect on the toxicity of DDT.

Bordeaux reduces the toxicity of DDT decidedly.

Summer oil emulsion does not affect DDT alone or the DDT-Coposil combination but it still further reduces the efficiency of DDT-Bordeaux.

Tests with DDT Against Mature Codling Moth Larvae.

Mature codling moth larvae (26 to 36 per test) were rolled in pure DDT (Dodge & Olcott Co.), Gesarol A Dust (3% DDT) and Neocid (10% DDT in pyrophyllite; manufactured by Geigy Co.,) until thoroughly covered and then allowed to spin up in corrugated paper. All were alive 12 days later.

Larvae sprayed with Gesarol A Spray 10 pounds per 100 gallons (0.5 pounds actual DDT). All larvae were alive 12 days later.

Strips of corrugated paper were dipped in furnace oil solutions of DDT and dinitrocresol. Larvae were allowed to spin up in these strips 2, 6, and 10 days after treatment. Results are given in table 4.

Table IV. Mortality of Mature Codling Moth Larvae in Paper Strips Treated with Oil Solutions of DDT and Dinitrocresol.

Material per Litre of Furnace Oil		Larvae Placed	Living	Dead	Percent Mortality
		October			
DDT	20 gm.	8	14	20	59.0
DDT	20 gm.	12	15	15	50.0
DDT	20 gm.	16	28	0	0.0
DDT	10 gm.	8	24	10	29.0
DDT	10 gm.	12	24	5	17.0
DDT	10 gm.	16	24	3	11.0
DDT	5 gm.	8	32	0	0.0
DDT	5 gm.	12	28	2	7.0
DDT	5 gm.	16	26	2	7.0
Dinitrocresol	20 gm.	8	0	34	100.0
Dinitrocresol	20 gm.	12	0	29	100.0
Dinitrocresol	20 gm.	16	4	26	87.0
Dinitrocresol	10 gm.	8	22	13	37.0
Dinitrocresol	10 gm.	12	26	3	10.0
Dinitrocresol	10 gm.	16	28	1	3.0
Dinitrocresol	5 gm.	8	30	3	9.0
Dinitrocresol	5 gm.	12	28	2	7.0
Dinitrocresol	5 gm.	16	27	1	4.0

Larvae were dipped into various mixtures containing DDT until thoroughly wet, then allowed to dry before being placed in jars with untreated corrugated paper.

In the case of dibutyl phthalate the DDT remained in solution in this material, which is insoluble in water, and was emulsified with Triton X-100.

Table V. Mortality of Mature Codling Moth Larvae 12 Days after Treatment. (Larvae Dipped in DDT Mixtures)

Materials Per Litre of Diluted Spray	Living	Dead	Percent Mortality
DDT 6 gm., Triton X-100 5 cc., Acetone 50 cc.	8	11	58
DDT 2.4 gm., Triton X-100 5 cc., Acetone 50 cc.	8	10	56
None - Triton X-100 5 cc., Acetone 50 cc.	4	11	73
DDT 6 gm., Triton X-100, 5 cc., dibutyl phthalate 50 cc.	9	10	53
DDT 2.4 gm., Triton X-100, 5 cc., dibutyl phthalate 50 cc.	14	5	26
None - Triton X-100, 5 cc., dibutyl phthalate 50 cc.	17	3	15

Conclusions

DDT is apparently much too ineffective to have any use in trunk sprays against hibernating larvae.

E. I. du Pont de Nemours & Co., Inc.

H. F. Dietz, R. Sutton and M. C. Swingle, Grasselli Chemicals Department, Wilmington, Delaware.

CODLING MOTH FIELD CONTROL EXPERIMENTS - 1944 - WOODSIDE, DELAWARE

Source of material: Du Pont 25 percent DDT, both technical and recrystallized (105° C. m.p.), containing a minimum quantity of other conditioning agents, particle size not over 10 microns.

Combination: With FERMATE fungicide, 1 pound first cover, followed 1/2:3:100 Bordeaux in third, fourth, sixth seventh and eighth cover. No fungicide in second and fifth cover.

Effects on foliage and fruit: Moderate mottled, purple discoloration, and chlorosis appearing one month before harvest, but not increasing in intensity. Fruit appearance equal to, or better than any other treatment. Very heavy preharvest drop, probably due to severe mite injury.

Effect on parasites, and other beneficial insects: No direct observations.

Influence on abundance of mites, aphids and other insects: Very heavy, rapidly increasing mite populations which persisted to end of season. Mite populations on lead arsenate treatments and checks very low, usually not more than a few mites per twig.

Spray dates: Calyx (lead arsenate) May 8; Cover sprays, May 15, 22, 31; June 9, 19, 29; July 10 and 21 (last spray); Harvest dates, September 14 and 15.

Codling moth activity: First emergence May 8, continuous infestation of checks with no break between broods. No marked peaks observed. Small partial third brood, accounting for infestation in DDT treatments.

CODLING MOTH CONTROL WITH 25% DISPERSIBLE COMPOSITIONS - DELAWARE, 1944
(Eight Cover Sprays)

Insecticide (per 100 gal.)	Percent Fruits			Worms per 100 Fruits	Stings per 100 Fruits	Percent Dropped Fruits	Percent Leaves		
	Clean	Wormy	Stung				Normal	Injured 1/	Fallen
Recrystallized DDT 1 lb.	96	3	1	2.5	2	61	63	24	13
Technical DDT 1 lb.	90	7	3	9	4	72	54	32	14
Lead Arsenate 3 lb.	65	14	21	20	38	36	39	50	11
Lead Arsenate 3 lb. (plus 1/2 gal. of oil, in peak sprays)	81	8	11	11	17	38	58	30	12
Untreated	16	81	3	165	22	83	20	54	26
Growers Lead-oil-Bordo	54	19	27	30	73	--	--	--	--

1/ Mainly black rot infection. Fungicides same in all treatments, as shown above.

3

Harvest time Residues Determined by Total Cl Method, Essentially as Given in E.T. 211, U.S.D.A., in Cl Free Atmosphere

Sample		mg./sq. cm.	grains/lb.
Crystallized DDT, Untreated		0.026 - 0.027	0.053 - 0.054
Crystallized DDT, Acid Washed		0.021 - 0.021	0.050 - 0.051
Technical DDT,	Untreated	0.022 - 0.021	0.051 - 0.050
	Acid Washed	0.014 - 0.015	0.038 - 0.035
	Dry Brushed	0.013 - 0.012	0.032 - 0.030

Standard Oil Company of Indiana

C. R. Cleveland, Chicago, Illinois.

Formulations of oil with and without DDT were tested for the control of fruit insects, including pear psylla, rosy apple aphis, European red mite, apple maggot, and codling moth, in Michigan during the 1944 season. These tests and the results are to be reported in summary form in the near future in the mimeographed E- series of the Bureau of Entomology and Plant Quarantine.

serve

March 8, 1945

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Administration

Bureau of Entomology and Plant Quarantine

RESULTS OF CODLING MOTH INVESTIGATIONS, 1944

Part II

Work Conducted by the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

Not for Publication

(Not for Publication)

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This summary represents the contribution of the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine to the pool of information on the results of codling moth investigations carried on during 1944 which has been prepared in accordance with a request made by the Committee on the Codling Moth of the American Association of Economic Entomologists. As in previous years, this is a preliminary report, circulated for the information of those interested. It is subject to revision as further review of the data may indicate, and has the status of unpublished data, not subject to quotation without permission.

The work of the Division of Fruit Insect Investigations is carried on cooperatively with several Bureau and Department units, as well as with a number of State agencies. The Division of Insecticide Investigations has continued to contribute to the work reported herein, and joint field laboratories are maintained at Yakima, Washington, and at Vincennes, Indiana. The work in West Virginia is carried on jointly by the West Virginia Agricultural Experiment Station and the Bureau; the work in New York State is carried on similarly with the New York Agricultural Experiment Stations.

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BELTSVILLE, MARYLAND

E. H. Siegler, In Charge

Laboratory Experiments with Insecticides

Throughout the season of 1944, research on insecticides was carried out with newly hatched codling moth larvae from stock material obtained in the Glassboro apple district of southern New Jersey. Data on the effectiveness of potential insecticidal materials, alone or combined with diluents, fungicides, etc., were obtained by means of the apple-plug method. Most of the tests included about 100 apple plugs, each of which was infested with a single ready-to-hatch codling moth egg.

Synthetic organic compounds:

In the broad field of synthetic organic compounds there are good possibilities of finding materials which would have excellent insecticidal properties. This laboratory has therefore continued its search for promising substances. In the course of these studies, certain of the materials gave, in initial test, results which were more favorable than those obtained with lead arsenate.

Insecticides from plant materials:

A plant obtained from Mexico and identified as Erigeron affinis has given evidence of promise. A petroleum-ether extractive of the roots, used at the dosage of 4 pounds of the extractive per 100 gallons of the carrier, produced 100 percent mortality of newly hatched codling moth larvae.

Extractives of seeds of the yam bean gave evidence of toxicity, but this was lower than that obtained with Erigeron affinis. It is of interest in this connection that many other species of Erigeron indicated no outstanding promise. Included in this category are: Erigeron divaricatus, Erigeron canadensis, Erigeron modestus, and Erigeron divergens.

Another plant which also showed good promise was an unidentified species of Ryania. An effective extract was obtained from its roots. Certain other plant extractives, which gave results of about the same order of toxicity as lead arsenate, were prepared from Delphinium sp., Amianthemum muscaetoxicum, Amorpha fruticosa, and Apocynum cannabium.

It should be called to the attention of the reader that the toxicity of plant materials may and frequently will depend upon the solvents employed, the part and age of the plant material, and other factors. For example, when Trypterygium wilfordii is treated with certain organic solvents, effective extractives are obtained; but

when hot water is used, the extractive is much less toxic. The following plants, although listed herein as having from fair to little promise, might have shown greater effectiveness if they had been treated differently: *Schkuhria abrotanoides*, *Helium mexicanum*, *Cocculus carolinus*, *Pristimera celastroides*, *Melinis minutiflora*, *Senicio ehrenbergianus*, and *Rauwolfia hirsuta*.

Compatibility of DDT combined with fungicides:

A few tests were made of DDT admixed with pyrophyllite and then combined with fungicides consisting of wettable sulfur, iron dimethyl dithiocarbamate (tank mixed), and lead dithiocarbamate (tank mixed). With respect to insecticidal effectiveness, DDT appeared to be approximately equally compatible with these fungicides.

Field Tests of DDT with New Fungicides

In cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering tests were made to determine the compatibility of DDT with several new and promising fungicides, from the standpoint of injury to foliage.

The spraying experiments were made in two orchards on the grounds of the cooperating Bureau at Beltsville.

In one orchard all trees were Delicious (bud-sport), 10 years old. The trees in the second orchard were of different ages and consisted of old Delicious, young Delicious, Golden Delicious, old Stayman, young Stayman, and Grimes. Each tree received five applications of spray and approximately 6 gallons per application.

The DDT was used at a strength of 1.5 pounds per 100 gallons of spray mixture, and had been mixed with an equal quantity of pyrophyllite. The following fungicides were included in the various spray mixtures (pounds per 100 gallons): Wettable sulfur, 8; ferric methyl dithiocarbamate (tank mixed) 1.5; disodiumethylene bis dithiocarbamate 1; ferric methyl dithiocarbamate (commercial) 1.5; lead dimethyl dithiocarbamate 1; dichloronaphthoquinone 1; morpholine thiuram disulfide 1.5.

No injury to the trees from the various treatments was apparent. There was no appreciable visible amount of residue on the fruit at harvest but this phase of the problem is being investigated by means of chemical analyses.

Both the apple crop and the codling moth infestation were very light and irregular, so the set-up was not ideal for experimental purposes. Because of this irregularity, detailed figures on codling moth control will not be given, but the results indicated that the toxicity of DDT ($1\frac{1}{2}$-100) when combined with various fungicides compares favorably with that of lead arsenate (3-100) with wettable sulfur.

Soil Treatments with DDT

Field experiments:

It was appreciated that the spraying of DDT in orchards would produce an accumulation of the chemical in the soil. In view of this, a study of the effect of DDT in the soil beneath apple and peach trees was commenced during the past season in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. Six bearing Rambo apple trees, 9 years old, with a spread of branches of about 16 feet, and 2 bearing Elberta peach trees, 10 years old, were selected for the experiments.

A mixture consisting of 5 pounds of DDT and 5 pounds of sandy loam was broadcast on one half of the soil area beneath each tree. As a check, the other half of the soil area beneath each tree was left untreated.

In non-bearing orchards of Rome apple trees (3 years old) and of Elberta peach trees (3 years old), a mixture of DDT and sand was broadcast in a fashion similar to that described above. Three quantities of DDT were used, 1, 2, and 3 pounds, each lot of which was mixed with 10 pounds of sand before it was distributed. Each of the above dosages was used on 2 apple and 2 peach trees.

It is too early to determine what the effects of these treatments may be. Up to the present time, no results are noticeable.

Decomposition of DDT by fertilizers:

In contemplation of using DDT sprays in orchards and in anticipation of the resulting accumulation of the chemical in the soil, a study was made to determine the possible effect of fertilizers on DDT. The following materials were furnished by the Bureau of Plant Industry, Soils, and Agricultural Engineering: Ammonium sulfate, manure salts, cyanamide, ammonium phosphate, potassium sulfate, "Uramon," steamed bone meal, dicalcium phosphate, milorganite, ammoniated superphosphate, double superphosphate, sulfate of potash-magnesia, potassium chloride, sodium nitrate, ammonium nitrate, and 6 commercial mixtures (8-8-8, 8-12-16, 5-10-5, 4-12-4, 4-10-6, and 3-9-6).

The chemical studies, which were conducted by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine, consisted in heating the fertilizer material with DDT at 115-120°C. for 1 hour, during which time any evolved hydrochloric acid was absorbed and titrated as a measure of the reaction. Any apparently unchanged DDT was then separated from the reaction mixture and examined for its identity. The basis for this procedure is due to the fact that certain materials cause a catalytic decomposition of DDT into hydrochloric acid and 2,2-bis(p-chlorophenyl)-1,1,-dichloroethylene. The latter has little value as an insecticide.

The only material which was found to catalytically decompose DDT under the conditions of the tests was dolomitic limestone. The catalysis occurred even though the dolomitic limestone was slurried with water and dried just prior to the test. Such treatment would have removed any catalytic agents such as anhydrous ferric chloride or aluminum chloride that may have been present.

Lures for Newly Hatched Codling Moth Larvae

Tests of extracts of apple:

The Division of Insecticide Investigations prepared 24 apple extracts, using 4 solvents (petroleum ether, ether, chloroform, and ethanol), for testing as possible attractants for newly hatched codling moth larvae. To determine what part of the whole apple contained the major portion of the attractant, separate extracts were made of the peel, flesh, and core of Rome apples.

Two ml. of each of the extracts were placed on filter paper and allowed to dry before testing in an olfactometer in which dry filter paper was used as a control. The results of the tests indicated that the ethanol extract contained a material or materials attractive to the larvae. Petroleum ether, ether, and chloroform extracts gave negative results.

Having first determined by means of an olfactometer that an ethanolic extract of apple peel was especially attractive to larvae, other studies were made to devise simpler means of observing larval reactions to the extract under other conditions. One of these procedures included the use of a round pane of glass, 12 inches in diameter, divided into 4 equal sections. Near the outer edge of each section a circle 2 inches in diameter was drawn. In the center of each circle there was placed a paper absorption block 1/2 inch in diameter and 3/4 inch high. One block was treated with undiluted ethanolic extract of apple peel, one with ethanol alone and two blocks were left untreated. As a result of 22 tests, it was found that 72 percent of the larvae were attracted to the block containing apple-peel extract, 19 percent to the ethanol-treated block, and 5 and 4 percents to the untreated blocks.

Miscellaneous tests:

In testing certain organic compounds and other materials as possible attractants for newly hatched codling moth larvae, five different quantities of each material were tested, namely: 12.5 mg, 25 mg, 50 mg, 100 mg, and 200 mg. Two ml. of ethanol were used as a control. The following materials were tested: Thiocyanogen, 1,2,3,4 tetrahydro carbazole, thiophenyl urea, thiodiphenyl, carbamide chloride, tetrachlorophenol, bis(methyl lactate) maleate, ethoxyethyl lactate, bis(allyl lactate) citraconate, 4 phenyl morpholine,

alpha naphthylamine, p-bromo-N-ethylbenzenesulfonamide, p-bromo-N-propylbenzene sulfonamide, p-bromo-N-isobutylbenzene sulfonamide, p-bromo-N-amylbenzene sulfonamide, bromo-N-benzylbenzene sulfonamide, 4-phenylmorpholine, N-isobutylbenzamide, N-butyllauramide, benzamide, p-chlorophenoxyacetic acid, 4(p-methoxy-alpha-thiotoluyl)morpholine, p-bromo-N-(p-chlorophenyl)-benzenesulfonamide, p-bromo-N-(o-chlorophenyl)-benzenesulfonamide, o-chlorophenoxyacetic acid, p-hydroxyacetophenone, and an ethanolic extract of apple peel.

With the exception of ethanolic extract of apple peel, none of the materials was attractive. 4-Phenyl morpholine proved to be very toxic to the larvae.

Tests of artificial flavors:

All materials were used in an olfactometer at the rate of 0.02 ml. Three controls were used--apple, dry paper, and moisture. The synthetic flavors were pear, crab apple, peach, peach bud, cherry, plum, grapefruit, orange, lemon, mint, raisin, lime, apricot bud, quince, maple, cinnamon, orange flower, brandy, wine, and champagne. None of the artificial flavors proved attractive. In all cases the apple was more attractive than the other controls and more of the larvae were attracted to moisture than to dry paper.

POUGHKEEPSIE, NEW YORK

P. J. Chapman and J. L. Brann, Jr., New York Agricultural Experiment Station, and D. W. Hamilton, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the New York Agricultural Experiment Station at the Hudson Valley Fruit Investigations Laboratory, Poughkeepsie, N. Y.

Seasonal Developments

Mortality to overwintering codling moth larvae for 1943-44 under paper-burlap bands in orchards throughout the Hudson River Valley was only 4.5 percent. In 1942-43 similar counts showed a mortality of 82.5 percent. In general, weather conditions during the growing season were favorable for codling moth development, although June temperatures were slightly below average and rainfall above average. Injury throughout the Hudson Valley in 1944 was the most severe ever recorded. The main reasons for this increase, listed in order of their importance, are:

1. Low winter mortality, excellent emergence and oviposition conditions during early spring flight, May 18-June 2, and good entry

weather for newly hatched larvae late in June and early in July. The season was slightly prolonged, unusually warm, and abnormally dry. Weather for second-brood development was ideal.

2. There was an abnormally high spring population of moths, because of a heavy build-up in 1943 from a light carryover the previous season.

3. Codling moth injury has been gradually increasing in the Hudson Valley area for the past 10 to 15 years. This is probably due primarily to increase in mean temperatures and decrease in rainfall. There may also have been a gradual building up of arsenical resistant codling moth strains. There has been an increase in the number of mature trees of so-called soft varieties, such as McIntosh and Cortland, that favor rapid codling moth increases. These larger trees are difficult to spray properly and afford excellent hibernation quarters for mature larvae.

TABLE 1. - Meteorological Data - May-August, 1944 - Poughkeepsie, N. Y.

Data Recorded	May	June	July	August
Temperature				
Mean	64.0	67.6	74.0	71.4
Deviation of mean (1937-1944)	+4.3	-0.3	+1.9	+1.4
Maximum	90	92	94	97
Minimum	38	46	55	46
Sunset mean	64.8	67.3	73.5	73.6
No. days sunset below 60°F.	7	3	0	0
Precipitation				
Total (inches)	1.77	5.78	4.09	2.61
No. days occurred	9	15	11	10
Deviation (1937-1944)	-2.02	+1.00	-0.62	-0.95

Pupation of codling moth larvae began May 1 as compared with May 7 in 1943. Moths were first taken in bait traps May 19 as compared to May 24 for 1943. First entries were found at Poughkeepsie June 3 and Kinderhook June 4, as compared to June 8 and 12 for the same localities in 1943, indicating that temperatures throughout the Hudson Valley were more uniform and somewhat advanced when compared to the previous season. Mature larvae began leaving the fruit June 30. Second brood adults began emerging in the insectary July 11, and first brood adults began coming to bait traps in orchards in large enough numbers to reflect increases in captures by July 22. Second brood injury increased to the extent where protection by sprays was desirable from July 24 to August 4, the variation depending upon the location of the orchard and extent of first brood control obtained. Peak flights of moths as measured by bait trap captures occurred May 29-June 2, August 2-4, and August 9-12. Weekly records of injury

as determined by the removal of injured apples from two unsprayed trees in the Kinderhook area are compared with similar records from the same orchard for 1943 in Table 2. The percent of second brood injury recorded is less than that normally occurring due to the decrease in the number of fruit present on the trees in August.

TABLE 2.- Codling Moth Injury by Weeks, Kinderhook, N. Y. Agricultural Experiment Station Orchard

2 McIntosh Trees 1943-1944

1943			1944		
Date Examined	No. Injuries	Percent of Injury Stings	Date Examined	No. Injuries	Percent of Injury Stings
June 12	First entry found		June 4	First entry found	
June 18	251	27.1	June 9	134	20.9
June 26	335	35.5	June 16	362	38.1
July 2	350	47.1	June 23	485	31.3
July 9	147	44.9	June 30	499	20.4
July 16	206	45.6	July 7	560	17.0
July 23	86	39.5	July 14	341	17.3
July 30	173	24.9	July 21	123	18.7
August 5	524	5.5	July 28	43	34.9
August 13	479	7.7	August 4	78	7.7
August 20	279	7.9	August 11	170	5.3
August 27	311	9.0	August 18	175	10.9
September 2	123	8.1	August 25	84	3.6
September 11	113	6.2	September 1	53	20.8
			September 8	42	16.7

Field Tests of Insecticides

Spray experiments - full-season:

Twenty spray schedules were compared on randomized single-tree plots, replicated four times in the Kinderhook area. Medium-sized McIntosh trees, well pruned, located on level ground, were used for these tests. The same orchard was used as in 1943 and an examination of the 1943 results will show the initial infestation present in this orchard. Codling moth injury in this locality has been severe for the past decade.

All plots except number 1 received early season sprays consisting of a calyx and a curculio application, each containing 3 pounds of lead arsenate and 1 pound of lime per 100 gallons and a special scab application using 1 pint of lauryl isoquinolinium bromide (Isothan Q-15)

per 100 gallons. Micronized sulfur was included in the calyx, curculio, and first cover applications at the rate of 6 pounds per 100 gallons on all plots. Generally 6 cover sprays were applied for codling moth protection. The first 4 were timed against first-brood worm activity and the last 2 against second-brood worm attack. A third second-brood cover should probably have been applied to all except the DDT plots for maximum protection and efficiency. The dates on which applications were made and the amount of rainfall occurring between applications follow.

Dates of Application		Rainfall (Inches)
Calyx	- May 17	---
Curculio	- May 27	0.36
1st cover	- June 6-7	1.23
Special scab	- June 15	--- (Not recorded)
2nd cover	- June 16	1.27
3rd cover	- June 27	2.70
4th cover	- July 6	0.25
5th cover	- August 2-3	4.94 (Bt. broods)
6th cover	- August 14-15	0.50
	August 15-31	1.54
	Total	12.79

Treatments tested and results obtained are shown in Table 3. Schedules have been grouped so that similar materials may be readily compared.

TABLE 3 - Codling Moth Spray Experiments - N.Y.S. Orchard, Kinderhook, N.Y. - 1944
Variety - McIntosh

Plot	Covers	Materials 1/ (Amounts per 100 gal.)	Apples per tree	Apples clean Percent	Number per 100 apples: Worms	Number per 100 apples: Stings	Harvest residues 2/ Gr. per lb. fruit
1	0	No insecticides	1306	25.8	165.2	26.2	.001 As_2O_3 .002 Pb.
		Lead Arsenate					
10	1-2	LA 3 lbs., L 1 lb.	1445	44.4	79.7	44.4	.009 As_2O_3 .021 Pb.
19	1-6	LA 3 lb., L 1 lb. 2 ozs. B-1956 in 3-6 covs.	1578	65.0	12.3	45.5	.094 As_2O_3 .191 Pb.
		DDT					
2	1-6	DDT, 2 lb.	1737	92.8	2.7	5.8	.044 DDT
3	1-6	DDT, 4 lb.	1487	96.7	0.5	2.7	.075 DDT
4	1-2 3-6	LA 3 lb., L 1 lb. DDT 4 lb.	2243	92.9	1.8	6.4	.072 DDT
		Phenothiazine					
17	1-6	Pheno 1 lb., kero. 2 qts. BA 8 ozs.	1893	78.7	18.5	9.4	
16	1-6	Pheno 2 lb., kero.2 qts. BA 8 ozs.	1580	83.5	16.7	7.7	
18	1-4 5-6	Pheno 2 lb., kero 2 qts. BA 8 ozs. NS 1/2 pt. oil-B1956-2 qts.	1285	74.6	22.3	10.7	
		Nicotine (1-2 covs. LA 3 lbs, L 1 lb.)					
5	3-6	NS 1/2 pt. Bent. 3 lbs. oil-B1956-2 qts.	948	83.4	9.0	12.1	
8	3-6	NS 1/2 pt. oil-B1956-2qts.	1248	79.8	10.1	17.6	
9	3-6	NS 1/2 pt. oil 2 qts. BA 8 ozs.	2075	72.2	20.1	22.3	
7	3-6	N-Bent. 1 1/2 lb. oil - B1956 2 qts.	1707	72.1	14.8	19.2	
6	3-6	ERRL-N-oil 5 lbs. Oleic 800 cc: Na-car 1 1/4 lb. Deo-base oil 1/2 pt.	1682	72.3	21.4	19.2	

Plot	Covers	Materials 1/ (Amounts per 100 gal.)	Apples per tree	Apples clean percent	Number per 100 apples: Worms	Number per 100 apples: Stings	Harvest residues 2/ Gr. per lb. fruit
		Nicotine (1-2 covs. LA 3 lbs. L 1 lb.) **Continued**					
20	3-6	Prop. Nic. 1 pt., oil 2 qts.	879	67.7	29.5	23.0	
		Oil (1-2 covs. LA 3 lbs., L 1 lb.)					
15	3-6	Oil-B1956 2 qts.	1829	62.8	49.7	28.9	.011 As_2O_3 .024 Pb.
		Xanthone (1-2 covs. LA 3 lbs. L 1 lb.)					
12	3-6	Xanthone 1 1/2 lb. Additives: A 6 ozs., B 2 ozs.	2147	78.6	11.8	24.1	
		Combined (Non-wash Schedules)					
13	1-2	LA 3 lbs., L 1 lb., NS 1/2 pt					
	3,5-6	N-Bent. 1 1/2 lb., oil-B-1956 2 qts.					.019 As_2O_3
	4	LA 3 lbs. B1956 2 ozs.	1496	76.7	12.7	21.0	.041 Pb.
14	1	N-Bent. 3 lbs.					
	2	LA 3 lbs. NS 1/2 pt. L 1 lb.					
	3-4	LA 3 lbs. L 1 lb.B1956-2 ozs					
	5-6	N-Bent. 1 1/2 lb.,oil-B1956 2 qts.	1141	74.3	13.0	26.0	.020 As_2O_3 .043 Pb.

1/ LA = lead arsenate, L = lime, DDT = 50% DDT (Geigy GNB-A-DDT) diluted with 50% Pyrophyllite (Pyrax ABB) and Micronized, Pheno = Phenothiazine Micronized, kero = kerosene, BA = Blood albumin (actual blood 25% of total amount), NS = nicotine sulfate, oil-B1956 - No. 875 summer mineral oil containing 1 percent of B1956, B1956 = a proprietary oil soluble spreader principally pthalic glyceryl alkyl resin, Bent = Mississippi bentonite, N-Bent. = Proprietary nicotine bentonite containing 14 percent nicotine, ERRL-N-oil = nicotine copper fatty acid in Prorex C mineral oil prepared by Eastern Regional Research Laboratory as oil soluble nicotine compound type no. 44, nicotine content 8.1 percent, Oleic = oleic acid, Na-car = sodium carbonate, Prop. nic. = proprietary nicotine oil material containing nicotine alkaloid. Additives A and B = proprietary spreaders and stickers.

2/ Arsenic and lead analyses by A. W. Avens, Division of Chemistry, New York Agricultural Experiment Station.
DDT analyses by Division of Insecticides, U. S. Bureau of Entomology and Plant Quarantine.

A 6-cover lead arsenate program was included for purposes of comparison, although repeated analyses have indicated that 3 cover sprays of lead arsenate, applied not later than July 20, are all that can be used without exceeding the tolerances of lead and arsenic on harvested fruit. Control obtained with lead arsenate schedules was the lowest of any season on record. Six covers were less effective than 4 covers were during 1936 and 1937. One pound of lime used at this low dosage throughout the season for the first time did not prevent arsenical injury on the foliage completely.

Tested for the first time, DDT gave outstanding results. Early laboratory tests indicated that DDT concentrate (Geigy's GNB-A-DDT) was coarse and granular and no practical method could be found for wetting this material or getting the particles divided and suspended in the spray tank. The DDT used was mixed with equal parts of pyrophyllite and micronized. This material went into suspension when thoroughly agitated and was used in conjunction with wettable sulfur in the first cover spray. A heavy, white, blotchy residue formed on the fruit and foliage after spraying and harvested fruit had excessive visible residue present on it. One quart of soybean oil added to the above formulation in late-season pear psylla tests masked the residue without causing foliage injury. Prior to August 15, foliage on DDT-sprayed trees seemed dark green. By September 1 the foliage on DDT-sprayed trees seemed to be an off shade yellow although the trees maintained their leaves up to the normal time of dropping. Red mites were not a problem in the orchard used for codling moth tests although they were present in small numbers. Visual examinations indicated that the red mite populations on the DDT-sprayed trees were no greater than on those sprayed with lead arsenate or nicotine and oil, and somewhat less than those on the unsprayed trees.

Since phenothiazine is the only non-arsenical tested at this laboratory other than DDT that has offered possibilities of controlling both codling moth and apple maggot, further testing of this material seems warranted. Visible residues on the fruit at harvest were not considered excessive and the foliage was free from injury.

In nicotine bentonite plot 5 visible residues at harvest were somewhat excessive and the coloring of the fruit was mottled due to the bentonite present. Because of the poor finish, this spray is unsatisfactory for use in this locality except on apples used by the canneries. Limited amounts of sulfur-oil injury occurred on all trees receiving oil-nicotine sprays, even though the sulfur preceded oil applications by 20 days. This time interval should be extended. Sulfur-oil injury on plot 20 was severe. Plot 6 received a new material containing a nicotine oil soluble copper salt, compounded by the Eastern Regional Research Laboratory. Copper russet appeared on 99 percent of the fruit, usually at the point of run-off. Nicotine cuprous cyanide as compounded by the Eastern Regional Research Laboratory russetted the fruit so severely that its use was discontinued after making two applications.

Plot 13 is the present recommended spray schedule for the heavily infested codling moth and lightly infested apple maggot orchards in this locality. This program in average years, properly applied, has resulted in 90 to 95 percent clean fruit, but in the heavy infestation of this season only gave 76.7 percent clean fruit. The combined nicotine-lead arsenate-oil program tested in plot 14 was prepared for orchards having both severe apple maggot and codling moth problems, lead arsenate being applied at the period when apple maggot emergence is the greatest. Control of codling moth compared favorably with that obtained with the recommended schedule.

Second-brood tests with DDT sprays:

Limited field tests were made with a special DDT-synthetic oil emulsion, manufactured by the Naugatuck Chemical Company. This emulsion contained 11 percent actual DDT. It was readily mixed in the spray tank, did not leave any visible residue on the fruit or foliage, and did not injure the fruit or foliage. The orchard used was the same as that used for the other spray tests, with all plots replicated 4 times, but the number of fruit per tree was less as all trees with a full crop had been selected for the first 20 schedules. Control figures are shown in Table 4.

Table 4. - Second Brood Codling Moth Spray Experiments - N.Y.S. Orchard, Kinderhook, N. Y. - Variety: McIntosh

Plot	Covers	Materials 1/ (Amounts per 100 gallons)	Apples per tree	Apples clean percent	Number per 100 apples: Worms	Number per 100 apples: Stings	Harvest residues 2/ Gr. per lb. fruit
31	1-4	LA 3 lb., L 1 lb., B1956, 2 oz. in 3rd & 4th covers	490	55.2	75.2	60.7	0.033 As_2O_3 0.073 Pb.
26	1-4	Same as for 31					
	5-6	DDT-syn. oil 1 qt.	1119	63.5	11.1	45.1	
27	1-4	Same as for 31					
	5-6	DDT-syn. oil 2 qt.	738	67.6	8.1	46.0	

1/ DDT-syn. oil = a proprietary DDT-synthetic oil emulsion prepared by the Naugatuck Chemical Company, containing 11.7 percent DDT.

2/ Analyses by A. W. Avens, Division of Chemistry, New York Agricultural Experiment Station.

Dusting experiments - full season replicated plots:

Eight different dust programs were tested, on the Cortland variety. The first 6 were applied to 8 trees in each of 2 half rows, Plot 7 consisted of only 12 trees, in one row. Plot 8 consisted of 4 trees only, due to the scarcity of DDT, and infestation records were taken on all 4. A Niagara cyclone duster was used, the trees being dusted from both sides during each application. Eight applications of dust were made, 5 for control of the first brood, and 3 for the second. During the first brood, applications were made just after daybreak while the foliage was damp and wind velocities were at a minimum. Second-brood dusts were applied just before dark while the foliage was dry, to prevent build-up of visible residue just prior to harvest. The morning applications seemed to be the more desirable. The amount of material used at each application varied, but averaged about 3 pounds for medium sized trees.

The dates when the dusts were applied and the record of the rainfall that occurred between applications follow:

Cover Application	Date	Rainfall since preceding dusting (Inches)
	First Brood	
1	June 3	-
2	June 10	0.16
3	June 18	1.19
4	June 26	2.71
5	July 5	0.63
	Second Brood	
6	July 31	2.76
7	Aug. 7	0.43
8	Aug. 15	0.00
-	Sept. 4	0.70
	Total	8.58

The dust plots were separated from each other by two rows sprayed by the grower with modern equipment, with single nozzle guns. Four cover sprays were applied against the first brood, on May 31-June 1, June 5, 12, and 22, and July 1-3. In addition, a special application was made to the inside of the tree June 5. One application was made against the second brood July 31-August 1. The first 2 cover sprays contained (per 100 gallons) lead arsenate 3 pounds, hydrated lime 3 pounds, nicotine sulfate (40%) 1/2 pint. Sulfur, 4 pounds, was also included in the first cover spray. A special inside spray and the fourth cover spray included lead arsenate 3 pounds, lime 3 pounds. The third and fifth cover sprays consisted of a commercial nicotine bentonite 1 1/2 pounds, and oil emulsion (83% oil) 2 1/4 quarts. The sprayed trees received approximately 15 gallons per tree at each application.

Micronized sulfur was used in all dust mixtures except the one containing DDT. The phenothiazine was also micronized. The nicotine bentonite contained 14 percent of nicotine.1/ The oil used in certain mixtures had a viscosity of 100.

Infestation records were taken on 3 trees from each half-row (except in plots 7 and 8), making a total of 6 trees per plot. Record trees were paired with count trees in an adjacent sprayed row.

Detailed information on the spray and dust schedules tested and the results obtained are given in Table 5.

Table 5. - Comparison of Various Codling Moth Dust Schedules with Growers' Standard Spray Schedule. Poughkeepsie, N. Y., 1944

Treatment	Cover Sprays	Average Number Apples Per tree	Clean Fruit	Per 100 apples	
				Worms	Stings
(Dust figures in percent)			Percent		
1. L.A. 20, sulfur 80	1-8	2035	56.1	59.4	34.4
Sprayed		2469	76.0	23.6	16.2
2. L.A. 20, sulfur 78, oil 2	1-8	1845	68.1	34.4	24.9
Sprayed		2056	78.1	18.7	20.2
3. L.A. 20, sulfur 68, nic. bent. 10, oil 2	1-3,6,7				
L.A. 20, sulfur 78, oil 2	4,5,8	1695	74.6	21.9	22.2
Sprayed		2553	82.9	14.0	12.0
4. L.A. 20, sulfur 58, nic. bent. 10, oil 2, lime 10	1-3,6,7				
L.A. 20, sulfur 78, oil 2	4,5,8	2465	75.1	22.0	20.3
Sprayed		2381	80.7	21.1	14.0
5. L.A. 20, sulfur 58, nic. bent. 20, oil 2	1-3,6,7				
L.A. 20, sulfur 80, oil 2	4,5,8	2090	75.6	17.4	24.8
Sprayed		1659	81.5	17.8	11.8
6. Pheno. 20, sulfur 78, oil 2	1-6				
Pheno. 20, sulfur 80	7,8	3008	82.5	24.5	5.7
Sprayed		2258	82.9	12.7	11.6
7. L.A. 20, sulfur 58, nic. bent. 20, oil 2 (proprietary mixture)	1-3,6,7				
L.A. 20 sulfur 78, oil 2	4,5,8	2001	64.5	36.4	31.1
Sprayed		2248	78.6	14.5	14.9
8. DDT 5, pyrophyllite 95	1-8	2267	84.7	10.8	10.7
Sprayed		2647	81.5	13.1	14.3

1/ Black-leaf 155.

The 5 percent DDT dust was the most efficient, and the apples receiving it had fewer worms per 100 and more clean fruit than the fruit receiving the grower's spray treatment. Discrepancies between the control obtained in Plots 5 and 7 are unaccounted for since the basic formulations of the dusts were similar.

Lead and arsenic analyses by A. W. Avens, Division of Chemistry, New York Agricultural Experiment Station, showed the following residues (in grains per pound) at harvest: Sprayed fruit, As_2O_3- .007 to .012, Pb.- .019 to .028; dusted fruit, As_2O_3- .007 to .018, Pb.- .017 to .041. The DDT residues were .007 grain per pound, according to analyses made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, Beltsville, Md.

Conclusions of experiments with dusts, based on 3 years' experience are: Dusts are still considered as in the experimental stage and should not be recommended for replacing the spray program in heavy codling moth infestations. They can be successfully used in light infestations. In heavy infestations, dusts may be used as supplements to the spray program, as they can be applied rapidly and reduce labor. The efficiency of lead arsenate dusts is improved by the use of oil as a sticker. Processed nicotine bentonite added to oil-lead dusts improves the efficiency of such dusts and increases control in proportion to the amount used. Phenothiazine used at 20 percent offered some possibility as a dust and does not leave too much visible residue on the fruit at harvest. Preliminary tests warrant the further testing of phenothiazine, in combination with lead arsenate. Sulfur is not an ideal carrier for insecticides in dust form and its use should be avoided after scab is controlled, as sulfur causes cheek scald to fruit, especially when oil is included in the formulations as a sticker. Sulfur-oil dusts also cause sulfur-oil injury to the foliage. Sulfur was used during the 1944 season so that the 1943 and 1944 results would be comparable.

Evidence that adult moths are killed when contacted by dusts containing nicotine bentonite, and nicotine bentonite with lime was obtained by placing moths in screened cages in the trees prior to dusting and taking mortality counts 28 hours later. The average mortality in cages in trees sprayed with lead arsenate, with or without oil, was 27 percent; in trees dusted with lead arsenate, oil and nicotine bentonite, 70 percent; and in trees receiving a similar nicotine bentonite dust with 10 percent of lime, 85 percent.

First-brood suppression dust program:

An attempt to suppress first-brood codling moth to an extent where second-brood protection would not be needed was made in an isolated block containing 170 trees. Methods and dates of application were similar to those described for the replicated plots, a total of 5 covers being applied during first-brood activity without any second-brood applications. The dust used consisted of lead arsenate 20 percent, nicotine bentonite 20 percent, oil 2 percent, lime 20 percent, and sulfur 38 percent in 3 covers during peak moth flight, and lead

arsenate 20 percent, oil 2 percent, sulfur 78 percent in the last 2 covers when moths were not so active. The number of worms per 100 was 36.2 for the McIntosh and 27.1 for the Cortland. The number of stings for the two varieties was 17.5 and 19.9. This control is poor compared with that obtained with the better dusts in the full-season tests. Injury was hard to find at the end of first-brood activity, and had second-brood dusts been applied, good control would probably have been maintained throughout the season.

During the first-brood period the captures of moths in 5 bait traps in the dusted blocks dropped to a low point compared with those in a nearby sprayed block, which confirms the results obtained with caged moths. It is evident that applications of lead arsenate-nicotine bentonite-lime dusts reduce the number of female moths present within the orchard.

Laboratory Tests with Dormant Larvicidal Sprays

Sections of rough barked apple wood 8 inches long and 4-6 inches in diameter infested with 30 codling moth larvae were sprayed May 1 and 2 with dormant larvicides, for the purpose of killing the larvae prior to the time of adult emergence. Mortality counts were made May 23 and 29. Each material was applied to 3 log sections with a paint type sprayer using 42 pounds pressure and exposing the log to the spray, on a turntable, for 2 minutes in the insectary.

The materials tested werenot considered effective enough to warrant testing under field conditions, and detailed results will not be given. It may be of interest that DDT in Deobase oil (emulsified), applied to the logs either before or after the worms had spun cocoons, had little effect on them.

Drop Pick-up Studies

Investigations relating to the number of larvae removed by picking up McIntosh drops at 1- and approximately 7-day intervals, prior to harvest, were made on single trees. About 36 percent of the larvae were recovered from apples picked up at weekly intervals late in August and the first few days in September. The percent recovery dropped somewhat with later pick-ups. Since many of the worms present were lost in the cutting or rearing processes used, it is believed that the actual number of worms present was greater than that indicated. The second-brood worms drilled to the core within a few days after entering the fruit, and were still small and immature when the apples dropped. The picking up of drop apples at weekly intervals under McIntosh trees in 1944 would have helped reduce the overwintering infestations of larvae. The value of picking up drops other than McIntosh is questionable, since other varieties remain on the trees a longer interval after the larvae enter the core.

Bait Trap Experiments

In a Latin-square arrangement, where 5 different types of baits or traps were compared, the standard double quart glass trap, using oil sassafras 1/2 cc. per quart and No. 13 brown sugar, 1 pound per gallon, bait captured more moths during the first-brood period than the same type of traps and bait with the traps painted yellow or white. Sodium benzoate added to the bait after fermentation had started reduced fermentation and prolonged the time such baits were effective from 20 days to 65 days, making it necessary to change such baits only once during the season. Results during the second-brood period comparing unpainted glass traps and yellow glass traps and standard baits with baits to which sodium benzoate had been added duplicated those obtained in the first-brood tests.

Standard pear psylla traps using the principle of a sticky substance covering yellow 5" x 10" pieces of board (described by George H. Kaloostian and Manning S. Yeomans, circular ET-220 - "A Sticky Trap Board Used in Scouting for Pear Psylla"), did not capture a single moth when used in the second-brood series. Similar results with this trap were secured with oriental fruit moths in a peach orchard. When pint jars of oil sassafras-sugar bait were suspended at the bottom of each trap a few codling moths were captured. Lepidoptera do not adhere readily to these traps as the scales on these insects peel off and allow these insects to free themselves. Observations further indicated that night-flying insects are not generally captured by these traps.

Apple Maggot Investigations, Poughkeepsie, N. Y., 1944

R. W. Dean, New York Agricultural Experiment Station, Division of Entomology, in cooperation with the U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, Division of Fruit Insect Investigations.

In the standard apple spray schedule for eastern New York, lead arsenate is used in the first, second, and fourth cover sprays, the latter two corresponding to the first and second maggot sprays. In some seasons, the first maggot spray may more nearly correspond to the third cover spray, an application in which nicotine, with or without oil, is employed. Since nicotine is not effective in controlling apple maggot, increased infestations may result at such times. The first cover spray is applied some time before fly emergence starts, hence a material ineffective against the maggot but effective against codling moth could, theoretically, be used in this application. Such a program was tested in 1944, using 3 pounds of fixed nicotine plus a sulfur fungicide in the first cover spray and 3 pounds of lead arsenate plus fungicide in the second, third, and fourth cover sprays. The 1943 infestation in the test orchard was 96.6 percent. It was reduced to 41.0 percent in 1944, which is not an impressive reduction for a

heavy lead arsenate schedule. It may be explained, in part, by the orchard surroundings which permitted fly migration between apple trees and bordering woodlands. Also, the numbers of punctures per fruit were considerably less in 1944 than during the previous season, so that the reduction in maggot injury was somewhat greater than is indicated by the percentage of infested fruit. One difficulty arising from the use of this modified schedule is the reduction in plum curculio control resulting from the substitution of nicotine for lead arsenate in the first cover spray. In another orchard, where lead arsenate was employed in the calyx and curculio sprays, and fixed nicotine in the first cover spray, curculio control was 82.8 percent as compared to 87.9 percent where lead arsenate was used in all three sprays.

One application on June 23 of DDT-Pyrophyllite 1:1 at the rate of 2 pounds in 100 gallons did not control apple maggot. In 1943, the average infestation in this planting was 10.3 percent. In 1944 it was 35.4 percent. An unsprayed check tree averaged 26.3 percent injury in 1944.

Two applications of DDT-Pyrophyllite 1:1 at the rate of 2 pounds in 100 gallons on June 22 and July 14 reduced an infestation, estimated at 100 percent in 1943, to 25.3 percent in 1944. Both DDT spray programs included micronized wettable sulfur at the rate of 5 pounds in 100 gallons. There was no evidence of injury resulting from the use of DDT.

Micronized phenothiazine 2 pounds in 100 gallons, plus micronized wettable sulfur, was applied twice, on June 23 and July 14, to part of a prune orchard which was reported to be infested by apple maggot. An average of 0.0129 maggots per fruit was reared from the crop from 9 trees. Since previous infestations were not measured, no estimate of the degree of control can be made.

YAKIMA, WASHINGTON

E. J. Newcomer, In Charge (Fruit Insect Investigations),
and W. E. Westlake (Insecticide Investigations)

Seasonal Conditions

The winter of 1943-4 was somewhat warmer than normal and there was no mortality of codling moth larvae on account of it. The spring was about normal and somewhat cooler than that of 1943, and blooming of apples and application of the calyx spray were about a week later than in 1943. The summer was somewhat above normal and from September 4 to 12, inclusive, maximum temperatures ranged from 90 to 98°. This allowed the codling moth to be active until the middle of the month.

Five baits in the Rome orchard used for spraying experiments have caught the following numbers of moths in the last six years:

1939	- 44,153	1942	- 20,227
1940	- 38,160	1943	- 29,009
1941	- 28,678	1944	- 40,745

These fluctuations have been caused by variations in the infestation and in the length of the season.

Biological Studies

Moth emergence and egg deposition. Moths from overwintering larvae began to emerge April 28, the peak occurred May 29-31, and emergence continued until the third week of July, at which time first-brood moths were appearing. This brood reached a maximum during the first half of August, and by the middle of September practically all of the moths had emerged.

Egg deposition first occurred about May 13, and gradually increased until reaching a peak during the first week of June. Eggs were deposited throughout the summer and a second peak was reached late in August.

Larval development. The first larval injury to fruit was found May 25, and the peak of injury for the first brood was reached during the third week of June. The number of injuries to fruit gradually increased during July and in August and early September numerous new injuries occurred. Mature larvae began leaving the fruit during the last week of June and the largest numbers of first-brood larvae were found in bands the last ten days of July. Maximum numbers of second-brood larvae entered the bands at the end of September.

Orchard Spraying Experiments

Spraying experiments were made in two orchards in 1944. One of these was a Rome orchard which has been used for a number of years, and in which two sets of experiments, designated A and B, were made. The other one was primarily a Winesap orchard, but it also contained some Jonathan and Delicious apple trees and some Bartlett pear trees which were used for some tests with DDT. The Rome orchard is over 20 years old and it had a somewhat irregular crop averaging 10 boxes to the tree. The infestation was heavier than in 1943. The Winesap orchard was older and had a fairly uniform crop averaging 13 boxes to the tree, and the infestation was similar to that in the Rome orchard. Single-tree plots were used, replicated 8 times in each orchard. From each tree random samples of 250 apples were taken at harvest, including both picked and dropped fruit.

A calyx and six cover sprays were applied in each orchard as follows:

Spray	Rome orchard	Winesap orchard
Calyx	May 10-12	May 8-9
1st cover	May 23-25	May 20-22
2d cover	June 1-5	May 29-31
3d cover	June 13-15	June 10-12
4th cover	June 27-29	June 23-24
5th cover	July 21-25	July 19-21
6th cover	Aug. 11-15	Aug. 9-10

Deposit analyses for each major treatment were made on the Romes and Winesaps before and after the second to sixth cover sprays, inclusive, with a few exceptions, and the averages of these are shown in table 1.

Table 1.- Average spray residues expressed in micrograms per square centimeter. Yakima, Wash., 1944

Treatment 1/	Residue	Rome		Winesap	
		Before spray	After spray	Before spray	After spray
1	As_2O_3	16.8	38.8	13.9	27.5
2	DDT 2/	3.8	7.4	4.1	12.8
3	Xanthone 3/	6.6	50.9	3.8	27.0
4	Nicotine	3.3	7.0	2.0	5.1
5	Nicotine	3.2	6.2	3.0	5.8
6	Fluorine	29.4	73.1	27.0	64.1
7	Fluorine	26.2	60.9	22.1	50.1
8	Fluorine	20.5	40.8	-	-

1/ See table 2 for details of treatment.
2/ Averages are for fifth and sixth cover sprays only.
3/ Averages are for third to sixth cover sprays. Nicotine used in first two cover sprays.

The analyses were made by W. E. Westlake, Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine. Five trees were sampled for each treatment through the fourth cover spray but only three trees for each treatment were sampled before and after the fifth and sixth cover sprays. The samples were taken by clipping 25 apples at random from all parts of a tree and allowing them to fall into a tared container.

Each sample was prepared for chemical analysis by adding a measured amount of solvent to the container, turning the jar end-over-end in a rotating machine for 5 minutes and pouring off a portion of the solution for analysis. Six percent sodium hydroxide was used as the solvent for lead arsenate, 0.5 percent sodium hydroxide for nicotine, toluene for xanthone, benzene for DDT and hydrochloric acid (one part concentrated HCl to nine parts of water) plus chloroform for fluorine residues.

Arsenic was determined by the method entitled "Extension of the Rapid Volumetric Micro Method for Determing Arsenic", by C. C. Cassil, J.A.O.A.C. XXIV, No. 1, p. 196 (1941). Nicotine was determined by the colorimetric method of L. N. Markwood described in J.A.O.A.C. XXII, No. 2, p. 427 (1939), xanthone by the colorimetric method developed by Cassil and Hansen and fluorine by a zirconium-purpurin titration procedure developed by the Food and Drug Administration. DDT was determined by the method of Gunther in which is utilized the reaction whereby one mol. of HCl is split from each mol. of DDT upon treatment with dilute alkali. A photoelectric photometer was used to read color density in the colorimetric methods employed for nicotine and xanthone.

The average deposits of As_2O_3 and of fluorine were similar to those of 1943, and the residue from the 75% cryolite was somewhat less than from the 95% cryolite. The deposit of xanthone varied more, a greater percentage being lost between applications. The deposits of nicotine were somewhat less than in 1943, and there was not very much difference between the two nicotines used.

The results of the field spraying experiments are given in table 2, and the average number of apples per box is given in table 3. There was in general a somewhat greater percentage of infested fruit in the Rome orchard than in 1943 due in part at least to a lighter and less uniform crop. The Winesap orchard developed a fairly high infestation although in 1943 it had had practically a total crop failure.

In la the 3d and 4th cover sprays were delayed 5 and 12 days, respectively, in order to more evenly bridge the gap that has customarily occurred between the cover sprays for the first and second broods, and while this did not significantly improve the control it also didnot increase theinfestation.

Table 2.- Comparative efficiency of insecticides used in field spraying experiments. Yakima, Wash., 1944.

No.	Treatment (Quantities are for 100 gallons)[1]	Orchard A (Rome)		Orchard B (Rome)		Orchard C (Winesap)	
		% wormy	% injured	% wormy	% injured	% wormy	% injured
1	Lead arsenate 3 lbs.; mineral oil (emulsive) 1 qt.[2]; Colloidal 77 1/6 lb.	12.8	31.8	31.4	60.1	11.8	37.4
1a	Same as 1. 3d and 4th sprays delayed 5 and 12 days	11.4	30.2	-	-	-	-
2	DDT-Pyrax (1-2)[3] 1-1/2 lb.	9.4	24.7	-	-	-	-
3	Nicotine-bentonite as in 4, first 2 sprays; then xanthone 2 lbs.; stove oil 1 qt.; Colloidal 77 1/2 lb.	14.6	23.5	32.8	43.7	13.4	19.4
4	Nicotine-bentonite (dry mix 1-5), micronized 3 lbs.; mineral oil 1 qt.; oleic acid 4 oz.; aluminum sulfate 2 oz.	16.8	27.2	38.2	51.9	17.1	29.5
5	Nicotine-bentonite (dry mix 1-7½), micronized 4 lbs.[4]; mineral oil 1 qt.; oleic acid 4 oz.; aluminum sulfate 2 oz.	19.0	30.4	40.9	53.1	13.4	23.7
6	Cryolite (90%) 3 lbs.; mineral oil (emulsive) 1 qt.[2]; Colloidal 77 1/6 lb.	11.5	35.7	22.4	53.0	13.0	39.8
7	Cryolite (75%) 3 lbs.; as in 6	16.1	39.1	24.4	57.7	12.7	36.2
8	Sodium fluosilicate 3 lbs.; as in 6	40.9	61.3	-	-	-	-
	Differences required for significance (19 to 1)	7.8	9.6	9.8	11.1	6.0	8.4

1/ Calyx spray lead arsenate 2 lbs. to 100 gals. in all plots.
2/ Increased to 2 qts. in the 2d, 3d and 6th cover sprays. The lead arsenate, oil and Colloidal 77 were mixed with water in a small container and injected into the spray tank. In the case of the Cryolite the oil was injected separately to prevent the emulsion from breaking in the tank.
3/ DDT and Pyrax mixed in a pebble mill.
4/ No. 5 was same as No. 4 in the first cover spray.

Table 3.- Size of apples resulting from different spray treatments. Yakima, Wash., 1944.

Plot	Treatment 1/	Size (ave. number applex per box) Rome A	Rome B	Winesap	Jonathan
1	Lead arsenate 3 lbs.	81	78	123	131 2/
1a	Do	74	-	-	-
2	DDT 1/2 lb.	96	-	133 4/	134 4/
3	Xanthone 2 lbs.	80	85	145	-
4	Nicotine-bentonite, 1-5	82	90	151	-
5	Nicotine-bentonite, 1-7.5	81	95	138	-
6	Cryolite (90%) 3 lbs.	86	91	144	-
7	Cryolite (75%) 3 lbs.	85	98	145	-
8	Sodium fluosilicate 3 lbs.	94	-	-	-
9	DDT 1 lb.	115 3/	-	127 4/	166 4/
10	DDT 1/2 lb . mineral oil 1 qt.	82 3/	-	147 4/	194 4/
11	DDT 1 lb. mineral oil 1 qt.	67 4/	-	-	-

1/ For details of treatment, see table 2.
2/ Three trees only.
3/ Two trees only.
4/ One tree only.

The use of DDT at 1/2 lb. to 100 gals., mixed with Pyrax (2), resulted in the cleanest fruit, although the difference between this and lead arsenate (1), cryolite (6 and 7) or xanthone (3) was not significant. It is interesting to note that the ratio of total injuries to worms is not particularly different with DDT than with lead arsenate or cryolite. Other treatments using DDT on one to three trees each consisted of the same mixture as in 2 with the addition of 1 quart of mineral oil emulsion each time, and of twice the quantity of DDT and Pyrax (that is, 1 lb. of DDT to 100 gals.) with and without the oil emulsion. On account of the small number of trees and a light crop on some of them, nothing definite can be said about these variations in treatment as far as control goes, although the use of 3 lbs. of DDT resulted in fewer worms (3 to 9%) and the addition of mineral oil apparently reduced the infestation somewhat.

A serious infestation of the Pacific Mite (Tetranychus pacificus McG.) developed late in July in all of the trees sprayed with DDT, even in those where 1 quart of mineral oil was added. This was evidently due to interference with the development of the ladybird predator (Stethorus), although considerable numbers of this ladybird did develop and maintain themselves successfully on the trees sprayed with DDT. Later on the Seius mite developed and practically wiped out the Tetranychus infestation on many trees, although not until after

much damage had been done. The *Aphelinus* parasite of the woolly apple aphid was also interfered with and a very heavy infestation of this aphid developed in August and September in all of the trees sprayed with DDT. On the other hand, in the Winesap orchard, the rose leafhopper (*Typhlocyba rosae* L.) was almost entirely absent from the trees sprayed with DDT although common in the adjoining trees not so sprayed.

The foliage of the apple trees sprayed with DDT became browned or bronzed from the feeding of the Pacific Mite, and some dead areas developed on many of the leaves which appeared to be caused by the insecticide rather than by the mites. Similar dead areas also developed on leaves of Bartlett pear trees sprayed with DDT, although there were very few mites on these trees. No difference in these effects was observed from the different treatments of DDT. Many of the apple leaves dropped prematurely, and about half of the crop also dropped prematurely from Delicious and Jonathan trees sprayed with DDT. This drop did not occur on Rome or Winesap apples or on Bartlett pears. Nearly all of the apples sprayed with DDT were smaller than those sprayed with lead arsenate, but this may have been due entirely to the infestation of mites. These figures have little significance, however, as with the exception of plot 2 in the Romes, the number of trees sprayed with DDT was too small to give dependable results.

Preliminary experiments were carried on with the removal of residues of DDT. The standard washing solutions were comparatively ineffective. A maximum removal of approaximately 60 percent of the DDT spray residue was accomplished by using 2 percent oil in water followed by a wash in a wetting agent to remove residual oil.

Xanthone used at 2 lbs. (3) in a simpler formula than that used in 1942, which resulted in more fluctuation of deposit, resulted in about the same percentage of wormy fruit and in noticeably less stung fruit than lead arsenate. In two cases (Rome B and Winesap orchards) the percentage of injured fruit was significantly less. The infestation of mites was also less than in trees sprayed with other materials. These results agree with those of previous years. All things considered the xanthone gave the best results of any material used. No injury of any sort developed, although it cannot be used for the first two sprays on Jonathans and yellow apples as it has a tendency to russet them. The deposit is less conspicuous than from most of the other materials.

Nicotine bentonite at 1-5 had given good results in 1943, although the deposit was rather heavy and conspicuous, and it was thought that a 1-7.5 mixture might be less noticeable and just as effective. This was used in 5 and compared with the 1-5 mixture in 4. The 1-7.5 mixture gave about the same control as the 1-5 mixture. Both of them resulted in somewhat less wormy fruit and somewhat less stung fruit than lead arsenate, but only in the case of the total injured fruit from the 1-7.5 mixture on Winesaps was the difference significant. The percentage of wormy fruit on Romes was significantly greater than from 1/2 lb. of DDT. The deposit from the 1-7.5 mixture was practically the same as that from the 1-5 mixture.

As in 1943, cryolite (6 and 7) gave results comparable to lead arsenate, and there was no particular difference between the 75% and the 90% material. There is a tendency for cryolite to result in more stings, except in the heavier infestations. In 1943, sodium fluosilicate was tried on a couple of trees with good results. It was therefore used on an 8-tree plot in 1944 (8). The results were very poor, however, the fluoride deposit being less than from cryolite, and there was some foliage injury. In view of these results and the evidence presented at the fluorine tolerance hearing in June indicating that sodium fluosilicate residues would be much more dangerous to human beings than cryolite, there seems to be no use in testing this material further.

Dusting Experiments

Four applications of DDT-Pyrax dust were made with a small power duster, using two medium sized apple trees each for a 3% and a 6% dust. The dust was prepared by mixing two parts of Pyrax and one part of DDT in a ball mill and then further diluting the mixture with Pyrax to the desired concentration. About 3 pounds of dust were put on each tree each time. On June 21, after the four applications had been made, 200 apples were examined on each tree and 1.5% and 2.5% of the fruit was found to be worm injured on the trees dusted with 3% and 6% dust, respectively. At this time not over 0.5% of the fruit was injured on trees sprayed with DDT. The power duster used was too small to do a good job and it is possible that if this dust could be thoroughly applied, it would be very effective.

Tarpaulins were spread under one tree of each dust treatment before the first application was made and left until after the third application. Only one dead codling moth was found on the tarpaulins during this period, although other insects, including several species of ladybird beetles, lacewing flies, lygus bugs, flies, and a few aphids were killed.

Use of Sprays to Kill Hibernating Codling Moth Larvae on Trunks

Large scale orchard tests were made in three orchards in 1944. Sprays were applied March 14-31, using a regular portable gasoline-power sprayer, with one exception, with the pressure reduced to about 175 to 200 pounds. Eight-foot spray rods equipped with bordeaux-type nozzles were used except in one part of one orchard where comparison was made with spray guns. Approximately 4-1/2 to 5 gallons of spray was used per tree. As usual an attempt was made to cover the trunks and most of the rough bark part of the scaffold limbs. Examinations for kill were made about 2 weeks after spraying.

The "regular formula" was used in all three orchards, except that in one the spray concentrate which had been prepared with acetone had turned black in the iron container but was used nevertheless for both the "regular" and "modified" formulas before it was decided to discard it. The "revised" or modified formula was used in two orchards. The two formulas are shown below.

Quantities per 100 gallons	Regular formula		Revised formula
4,6 -Dinitro-ortho-cresol	4 lbs.	. . .	3 lbs.
Stove oil	10 gals.	. . .	15 gals.
Emulsifier: Tergitol 7	4 pts.	. . .	1/2 pt.
Penetrant: Ethylene glycol monobutyl ether	1.5 gals.		-
and Trichloroethylene . . .	1.5 gals.		-
		Ferric chloride .	3.78 grams

In 1943 the sprays were prepared in the orchard by dissolving the dinitro compound by heating. This year the toxicant was dissolved by agitation in acetone and this concentrate taken to the orchard where the other ingredients were added.

Although 62 to 65 percent of the overwintering larvae were killed by the spoiled dinitro spray in orchards no significant reduction compared with the check plot in the moth population was shown either for the spring brood or for the whole season, and the reduction in percent of wormy harvested fruit was not significantly different from the rate of reduction in the check as compared with 1943.

In orchard B, one-half of which was sprayed with the regular formula, using the grower's large stationary outfit, a kill of 88% was obtained. Here evidently there was a reduction in moth population or there was considerable migration from the sprayed plot into the check because the original overwintering population was 111 worms per tree in the sprayed plot and only 46 in the check or 2.4 times as many. While the bait pot catch was only 1.1 times as many, indicating a reduction of 54.5% at harvest, this apparent reduction showed its effect in that the check plot averaged 5.2% wormy compared with 8.1% in the sprayed plot, whereas there should have been an expected 12.6% wormy based upon the ratio of overwintering population in the two plots. It is apparent, however, that with such a handicap at the start of the test the 88% kill of the trunk spray was not sufficient

to overcome the difference and make the sprayed plot cleaner than the check. In orchard C, which was sprayed one-half with the regular formula and one-half with the revised formula, the kill was 95 and 56%, respectively. In this set-up the portable sprayer was used as a stationary, and there appeared to be considerable variation in the spray solution of the revised formula from time to time as it went on the trees. This may account, in part at least, for the poor kill. At blossom time practically all of the crop was killed by frost except in one small high corner and even there the crop was only about 1/10 of last year. No harvest counts of course were made.

Due to the lack of an ideal set-up with uniform population distribution throughout the orchard, and to the apparent necessity for a check which reinfests the treated plot, the full value of the trunk spray has not yet been conclusively demonstrated.

Test of Paradichlorobenzene to Kill Overwintering Larvae in the Soil at the Base of Apple Trees.

Continuing tests made annually for a number of years, paradichlorobenzene crystals at 1/2, 1, 1-1/2 and 2 ounces per tree, placed in the soil at the base of infested apple trees, again showed almost complete kills of 98 to 100%, respectively. (See Jour. Econ. Ent. 37: 448-50 for previous work.)

Test of Repellent Against Mature Larvae

Preliminary tests were made to test the phytocidal action of the best pyrethrum-cottonseed oil repellent developed in previous years: Pyrethrum extract 5%, cottonseed oil 10%, blood albumen emulsifier 6 gm., water to make 10 gallons. This formula, previously tested impregnated in corrugated paper bands, proved highly repellent to full grown codling moth larvae. (For previous work see Jour. Econ. Ent. 37 (probably Oct. No..)) This formula was used as a spray and applied with a bucket pump on June 28 to the trunks and scaffold limbs of 5 large, bearing apple trees. This proved injurious to fruit and foliage, but no injury was apparent to the bark of the trunk and limbs. All buds hit were killed, and most of the sprouts and twigs were defoliated. The few apples hit were specked by the oil in the spray.

It is apparent that at the concentration used it would be unsafe to use this spray where it would hit the fruit and foliage.

Summer Test of Trunk Spray

Summer tests were made of dinitro-o-cresol in stove oil emulsion and of DDT dissolved in benzene and then used in the stove oil emulsion applied on trunks and scaffold limbs of fruitless trees in July. At intervals of 3, 30 and 60 days after spraying, 200 larvae were placed on one tree for each of 5 formulas and an untreated check. At the end of 30, 60 and 90 days all individuals recovered were examined for mortality. The regular dinitro formula gave 82, 68 and 79% kill, and the DDT gave 85, 28, and 20%.

This indicates that most of the larvae attempting to cocoon on the dinitro- or DDT-sprayed surfaces were killed for the 30-day period, and that the dinitro spray was much more persistent than the DDT, which was no better than the checks after the 30-day period.

KEARNEYSVILLE, WEST VIRGINIA

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These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the West Virginia Agricultural Experiment Station.

Seasonal Conditions and Codling Moth Activity

The 1944 season in the Cumberland-Shenandoah region was quite favorable for codling moth development and activity. In this immediate area a dry warm spring was followed by a continuously warm and dry summer with drought conditions in sections. The first codling moth taken in the bait pails May 9 preceded by 2 days the first emergence from bands in the emergence cages. The spring brood peak was reached in the emergence cages May 15 and in the bait pails May 16. By the end of May 87 percent emergence had occurred in the emergence cages and bait pail collections had dropped sharply. First entrances were noted on fruit May 20 and first exit June 10. Spring brood trap collections were approximately three times as great as in 1943 and total season's collections approximately four times as great as in any of the preceding 3 years. Second-brood damage was unually severe, and a high worm population entered hibernation.

Field Tests of Insecticides

The field experiments with insecticides for control of codling moth were conducted in a block of York trees in the Border Orchard near Kearneysville, W. Va. A heavy infestation of codling moth carried over in this orchard from 1943. All plots were single tree plots selected at random. Plots 1 through 18 were replicated five times, while Plots 19 through 32 had no replications, but were established for the purpose of utilizing the small quantity of DDT available to this station to develop leads to further tests when adequate supplies are available.

Arsenicals: Ten replicated plots were based on lead arsenate in varied combinations and schedules, none of which appeared to be significantly more effective than the standard 4-cover schedule (Plot 1). Heavy Bordeaux and Fermate materially reduced the effectiveness of the lead arsenate with respect to total injuries, worms, and stings. However, inter-tree migration in a single-tree plot set-up obscures evaluation of nicotine in the lead schedules and also in the tests of nicotine combinations and materials.

Nicotines: All nicotine plots were replicated and received 8 cover sprays. All plots produced a higher percentage of clean fruit and fewer stings than the standard lead schedule and all but 2 had fewer worms. Factory-processed nicotine bentonite produced the cleanest fruit with fewest worms and stings.

DDT: The 2 replicated plots (Plots 13 and 14) of DDT did not produce as high percentage of clean fruit for the season as did the best nicotine plot but had fewer stings. However, a comparison of the DDT plots which received only the first-brood sprays with plots receiving second-brood sprays is scarcely just to the material. Only the regular four first-brood cover sprays were applied and observations indicated that the DDT began to lose its effectiveness about 30 days after the last spray had been applied.

First-brood results with DDT were outstanding in both the replicated plots and the unreplicated single-tree plots and indicated that had the entire orchard been sprayed with this material the second brood would have been of little consequence. First-brood counts of tree and drop fruits on Plots 13 and 14 indicated only one worm to each 1574 apples or 3.7 worms per tree as compared with the standard lead arsenate plot with one worm to each 11.8 apples or 520 worms per tree.

The unreplicated plots (Plots 19-32 and 13XB and 13XD) can not be granted individual significance. However, no one of the plots receiving 4 first-brood cover sprays of DDT in any combination had more than 1.5 percent total fruit injury at the end of the first brood. This further substantiates the conclusion that second brood would have been of no consequence had the entire orchard been sprayed with this material. This also indicates that when used in the 4 first-brood cover sprays at the rate of one pound of active DDT the addition of nicotine, oil, or bentonite did not materially reduce its effectiveness against the first brood. Likewise, when used at the rate of one-half pound active DDT in combination with nicotine-bentonite-oil, Bordeaux-lead arsenate or zinc sulfate-lime-lead arsenate first-brood control was effective. Examination of the final season's results of plots 13, 14, and 19 through 27 indicates a loss of toxicity of DDT against the second brood. The plots sprayed with aqueous emulsion of DDT-benzene and DDT-xylene emulsions indicated that the material in this form retains its toxicity longer.

Plot 28 indicates very good control with DDT in the last 3 first-brood cover sprays. Plots 29 through 32 indicate decreasing effectiveness with decreasing concentrations with the effectiveness of one-half pound of active DDT about the equivalent of 3 pounds of lead arsenate in the control effected. Plot 19 indicates that 3 covers of DDT were very effective in control of first brood and on an orchard-wide scale may suffice.

Sample apples from Plots 13, 14, 25, and 27 were collected on September 27 and submitted to the Division of Insecticide Investigations for analyses of DDT residues. Residues (grains per pound) were reported as follows:

Plot 13 - 0.026
Plot 14 - 0.019
Plot 25 - 0.031
Plot 27 - 0.052

Oils: Some foliage injury and a roughness of finish was noted on plots receiving the 8 cover sprays in all of which oil was used. An average of 8.8 quarts of oil per tree was applied on Plots 8 through 12, and 5.6 quarts per tree on Plot 7. This appears to be too much oil for this area under conditions existing this season.

A serious population of European red mite developed during July on all plots sprayed with DDT and a spray of 6 quarts of summer oil emulsion per 100 gallons was applied on August 8. Rather severe injury had already occurred from this insect by this date and considerable defoliation resulted on some of the plots. Heavy fruit drop on the DDT plots occurred, but due to the severe mite damage and resultant defoliation it could not be determined that DDT was a direct factor in this drop. The mite population on plots other than DDT was of no consequence, and fruit drop on those plots could be correlated somewhat with degree of worminess.

Table 1 summarizes the spray schedules and results of the various plots.

Dates of the sprays were as follows:

1st - May 17-20 (except plots 16 and 19 were May 23)
2nd - May 27-June 1
3rd - June 7-8 (except plots 16 and 19 were June 16)
4th - June 23
5th - July 12
6th - July 25
7th - August 8
8th - August 23

Following is a list of materials used and explanation of symbols used in table 1:

B - Mississippi bentonite (Panther Creek Brand)
BL155 - Black Leaf 155 (regular) containing 14% nicotine
BL155 Spec. - Black Leaf 155 special containing 14% nicotine
Bordo - Bordeaux mixture
25%DDT - Powdered material prepared by DuPont containing 25% active DDT
50%DDT - DDT concentrate of Geigy Co. micronized with equal amount of pyrophyllite
Fermate - ferric dimethyl dithiocarbamate
FS - Flotation sulphur
20XN - Liquid material prepared by California Spray Chemical Co. and containing 14% nicotine alkaloid and a lethane
L - hydrated spray lime
LA - lead arsenate (Orchard Brand)
N - nicotine sulphate 40% (Black Leaf 40)
O - summer oil emulsion containing 83% oil (Orthol-K)
Zn - zinc sulphate (granular)
1/ - Total of 4 drop fruit collections and harvested fruits
* - Indicates unreplicated single-tree plots.

Table 1 - Results of field experiments with insecticides for control of codling moth in 1944.
Border Orchard - Kearneysville, West Virginia

Plot No.	Cover Sprays	Materials Amounts per 100 Gallons	Total Fruits	First Brood Counts Percent Clean	First Brood Counts Per 100 Fruits Worms	First Brood Counts Per 100 Fruits Stings	Season Counts 1/ Percent Clean	Season Counts 1/ Per 100 Fruits Worms	Season Counts 1/ Per 100 Fruits Stings
1	1	LA 3#, L 3#, FS 5#							
	2-3	LA 3#, ½-2 Bordo							
	4	LA 3#, 2-4 Bordo	30,564	70.1	6.1	40.0	26.7	101.4	124.0
2	1	LA 3#, L 3#, FS 5#							
	2-4	LA 3#, 4-8 Bordo	26,678	57.8	10.6	65.4	11.5	178.7	221.5
3	1-4	LA 3#, ½-2 Bordo	23,842	60.6	10.2	58.1	17.5	145.9	157.3
4	1-4	LA 3#, Zn ½#, L 2#	23,690	58.2	9.9	68.1	18.6	110.2	173.4
5	1-3	LA 3#, ½-2 Bordo, N 3/4 pt.							
	4	LA 3#, 2-4 Bordo	16,866	60.5	7.1	55.7	14.9	173.0	194.5
6	1-3	LA 3#, ½-2 Bordo, 20 XN 3/4 pt.							
	4	LA 3#, 2-4 Bordo	21,788	59.3	9.2	59.9	14.3	144.7	214.9
15	1	LA 3#, FS 5#, N 3/4 pt.							
	2	LA 3#, ½-2 Bordo, O 3 qt., N 3/4 pt.							
	3	LA 3#, ½-2 Bordo, O 3 qt.							
	4	LA 3#, 2-4 Bordo	32,225	80.8	1.8	22.6	28.4	103.5	140.5
16	1	LA 3#, ½-2 Bordo, N 3/4 pt.							
	2	LA 3#, ½-2 Bordo, O 3 qt.							
	3	LA 3#, 2-4 Bordo.	28,626	68.8	3.6	42.3	19.7	125.0	169.5
17	1	LA 3#, Zn ½#, L 2#, N 3/4 pt.							
	2	LA 3#, Zn ½#, L 2#, O 3 qt., N 3/4 pt.							
	3	LA 3#, Zn ½#, L 2#, O 3 qt.							
	4	LA 3#, 2-4 Bordo	32,037	80.1	2.2	24.7	29.1	85.8	129.7
18	1	LA 3#, Zn ½#, L 2#							
	2	LA 3#, Fermate 1½#							
	3-4	LA 3#, Fermate 1#	21,146	61.3	11.3	66.1	12.3	174.8	184.6

Table 1 - Continued

Plot No.	Cover Sprays	Materials	Total Fruits	First Brood Counts: Percent Clean	First Brood Counts: Per 100 Fruits Worms	First Brood Counts: Per 100 Fruits Stings	Season Counts: Percent Clean	Season Counts: Per 100 Fruits Worms	Season Counts: Per 100 Fruits Stings
7	1	N 1 pt., B 5#, O 1 qt.							
	2	N 1 pt., B 5#, O 2 qt.							
	3-4	N 1 pt., B 8#, O 2 qt.							
	5	N 2/3 pt., B 5#, O 1 qt.							
	6-8	N 2/3 pt., B 5#, O 2 qt.	17,902	81.4	3.7	17.7	55.2	46.0	34.1
8	1	BL155 2#, O 1 qt.							
	2-8	BL155 2#, O 3 qt.	24,224	84.5	2.1	16.4	71.6	21.5	29.4
9	1	BL155 Spec. 2#, O 1 qt.							
	2-8	BL155 Spec. 2#, O 3 qt.	26,383	85.5	1.3	15.4	53.6	49.0	37.5
10	1	N 1 pt., B 5#, O 1 qt.							
	2-8	O 3 qt.	17,618	80.4	10.8	13.1	35.4	126.0	40.1
11	1	20XN 3/4 pt., B 5#, O 1 qt.							
	2-8	20XN 3/4 pt., O 3 qt.	18,836	75.0	11.0	20.5	30.6	141.8	56.4
12	1	N 3/4 pt., B 5#, O 1 qt.							
	2-8	N 3/4 pt., O 3 qt.	19,905	85.9	1.9	14.4	45.3	59.2	62.7
13	1-4	25% DDT 4#	27,556	99.1	0.1	0.8	60.4	47.8	19.9
14	1-4	50% DDT 2#	30,925	99.3	0.0	0.7	67.0	38.2	13.4
19*	1-3	DDT-Benzene(1#-1qt.)emulsified	7,503	96.0	0.5	4.0	54.0	59.3	17.5
20*	1-4	50% DDT 2#, N 3/4 pt.	8,877	99.5	0.0	0.5	63.6	43.0	10.0
21*	1-4	50% DDT 1#, LA 1½#, Zn ½#							
		L 2#	11,757	99.0	0.0	1.0	43.3	80.8	28.5
22*	1-4	50%DDT 1#, LA 1½#, ½-2 Bordo	3,732	99.5	0.0	0.5	50.9	72.1	40.4
23*	1	50%DDT 2#, O 1 qt.							
	2-4	50%DDT 2#, O 3 qt.	2,367	98.5	0.0	1.5	54.4	23.7	74.2

Table 1 - Continued

Plot No.	Cover Sprays	Materials	Total Fruits	First Brood Counts Percent Clean	Per 100 Fruits Worms	Per 100 Fruits Stings	Season Counts Percent Clean	Per 100 Fruits Worms	Per 100 Fruits Stings
24*	1	50%DDT 1#, N 3/4 pt. B 5#, O 1 qt.							
	2-4	50%DDT 1#, N 3/4 pt. B 5#, O 2 qt.	2,379	99.0	0.0	1.0	31.9	94.3	85.3
25*	1-4	DDT-Benzene(1#-1 qt.) emulsified	4,331	99.5	0.0	0.5	84.6	8.4	12.6
26*	1-4	50%DDT 2#, B 5#	5,456	99.5	0.0	0.5	63.3	51.5	18.9
27*	1-4	DDT-Xylene (1#-1 qt.) emulsified	3,727	100	0.0	0.0	93.1	4.3	4.1
28*	1	LA 3#, Zn 1#, L 3#, N 1 pt							
	2-3	50%DDT 2#, ½-2 Bordo							
	4	50%DDT 2#, 2-4 Bordo	9,022	85.0	0.0	17.5	72.5	9.4	29.5
29*	1	LA 3#, Zn 1#, L 3#, N 1 pt							
	2	LA 3#, ½-1 Bordo, N 1 pt., O 1 gal.							
	3-4	50%DDT ½#	6,216	52.5	8.0	70.0	7.9	213.8	133.0
30*	1	LA 3#, Zn 1#, Li 3#, N 1 pt.							
	2	LA 3#, ½-1 Bordo, N 1 pt., O 1 gal.							
	3-4	50%DDT 1#	5,212	81.0	0.0	27.0	27.0	79.8	80.7
31*	1	LA 3#, Zn 1#, Li 3#, N 1 pt.							
	2	LA 3#, ½-1 Bordo, N 1 pt., O 1 gal.							
	3-4	50% DDT 1½#	3,755	70.5	3.0	35.5	37.3	79.1	53.6
32*	1	LA 3#, Zn 1#, Li 3#, N 1 pt.							
	2	LA 3#, ½-1 Bordo, N 1 pt., O 1 gal.							
	3-4	50%DDT 2#	8,677	77.5	1.0	28.0	66.6	8.5	33.8
13XB*	1-4	25%DDT, 4# (Ben Davis variety tree)	4,223	100.0	0.0	0.0	58.4	34.2	33.3
13XD*	1-4	25%DDT, 4# (Delicious variety tree)	2,501	99.5	0.0	0.5	38.3	114.3	17.8

Practical test of tank-mix nicotine-bentonite

A practical test of tank-mix nicotine-bentonite was made on the station grounds. The schedule and materials were as in Plot 7 of Table one preceding. Three blocks of trees representing a number of varieties were given this coverage. The total number of trees involved was 470 and varieties as follows: Arkansas Black, Blaxtayman, Delicious, Gallia, Golden Delicious, Grimes Golden, Jonathan, McIntosh, N. W. Greening, Red Jonathan, Richared Delicious, Rome Beauty, Rome Red, Starking, Staymared, Transparent, Winesap and York. First brood counts of 200 apples from each of 5 trees showed 4.2 percent of total fruits injured with 3.5 stings and 0.9 worms per 100 fruits. Counts were not made throughout the season nor at the end of the season, but general observations showed that very good codling moth control had been effected and finish was good except for the oil roughness discussed previously. Some foliage injury was also noted from use of so much oil under this seasons drought conditions.

Codling Moth Population Build-up Studies

Codling moth population build-up studies were begun in an isolated, abandoned eight-acre orchard in 1941. The orchard was completely defruited in 1942. No codling moth control sprays were applied during 1943 or 1944. Table 2 shows clearly the rapidity with which codling moth population builds up under natural conditions.

At the beginning of the experiment in 1941 the orchard showed a first brood infestation of 14.1 percent with a total infestation of 48.5 percent. This was reduced to almost zero in 1942. The population was so nearly eradicated that in 1943 the first brood only built up to 2 percent with a total infestation of 12.1 percent. This relative light carry-over, however, gave a first brood infestation of 18.9 percent in 1944 with a total infestation of 71.2 percent. Thus the biotic potential of codling moth is such that in two favorable seasons under natural conditions it built up from practically zero to approximately its maximum level. The population was significantly greater in 1944 than at the beginning of the experiment due to an influence in the natural biological balance. The light crop in 1944 was also a contributing factor. The extremely light yields in 1943 and in 1944 might indicate a residual effect from the defruiting sprays. Further experiments along this line have failed to show any evidence of such residual effects. In the station orchard in 1943 Staymans, Winesaps, Delicious, Golden Delicious and Black Twigs were completely defruited with the oil-dinitro sprays. All trees of these varieties bore full crops in 1944.

Table 2. Comparative results 1941-44 Population Build-up Studies

	1941		1943		1944	
	1st Brood	Total	1st Brood	Total	1st Brood	Total
Total Fruits	106908	106908	36557	36557	20657	20657
% Injured	14.1	48.5	2.0	12.1	18.9	71.2
% Stung	7.0	7.7	1.7	5.7	9.0	4.5
% Wormy	6.3	32.9	0.3	5.0	8.1	52.2
% Wormy & Stung	0.9	7.9	-0-	1.4	1.9	14.5
Worms per 100	8	55	0	9	11	127
Stings per 100	9	19	2	9	13	24

VINCENNES, INDIANA

L. F. Steiner, In Charge 1/

Seasonal Conditions and Codling Moth Development

Total rainfall in April and May exceeded 10 inches, but during the 96 days from May 11 to August 14 it was only about 5 inches as compared with a normal rainfall of about 12. Between August 14 and 31 the rainfall was about another 5 inches - equal to that of the preceding 3 months. A light bloom, poor weather for pollination, and freezes on May 6 and 7 resulted in about 40 percent of a full crop.

There was a heavy carryover of worms. Moth emergence began May 2, but activity remained at a very low level until the weather became favorable, about May 9. Catches in 112 traps in 4 orchards increased from 5 moths on May 9 and 10 to a record peak of 4,519 on May 18 with more than 19,000 being taken between May 16 and 20. The total catch for the season amounted to 78,500 moths. First-brood hatch began May 17 and within 10 days codling moth injuries on plots receiving standard treatments averaged 4.5 per 100 apples. Few growers were ready for the unusually early and heavy hatch that occurred from 3 to 4 weeks after petal fall and preceded the 3rd cover spray in most orchards. Mature larvae began leaving apples June 5, adults appeared June 18 and the second-brood hatch reached its peak before July 15. Third-brood larvae began hatching early in August, there being evidence that a light fourth brood developed.

The average mean daily temperature during July was 79.7° and during the first 18 days of August, 83.1° with no temperatures over 100° to kill the eggs and none under 60° until after August 19 to prevent moth activity at dawn and dusk. By August 1 the average infestation throughout the area was as great as it was at harvest in 1943 and at harvest the infestation on certain lead arsenate and nicotine bentonite plots sprayed with the same formulas as in 1943 was three times as great with crops of the same size and despite the application of much more material in 1944. The average infestation in southern Indiana, southern Illinois, and western Kentucky was in excess of 50 percent wormy fruit. Despite the application during the season of more than 14 pounds of lead arsenate each, to trees of moderate size with yields of from 1,500 to 3,600 apples, the crops on 3 varieties ranged from 56 to 76 percent wormy with from 208 to 359 injuries per 100 apples.

The present worm carryover in most orchards is of record size.

1/ All chemical analyses reported herein were made by J. E. Fahey, Division of Insecticide Investigations. Mr. Fahey also processed most of the DDT used in these experiments.

Laboratory Experiments with Insecticides

Tests, utilizing not less than 40 apples and 400 newly hatched larvae each, were conducted early in the year in extensive studies of DDT (Bureau of Entomology and Plant Quarantine Circular E-628, 17 pp., November 1944).

Results of an additional experiment conducted in June and repeated in July are summarized below:

Formula (4 ozs. DDT per 100 gals. in each)	Percent larvicidal efficiency 6/9/44	7/4/44
1. DDT-Pyrax (1:1) (1943) (Raymond Hammer Mill)	94.2	99.4
1a. No. 1 after exposure to 5 tap water sprays	88.1	57.5
2.1/ DDT-Kaolin (1:1) (Mikropulverizer)	94.9	93.7
2a. No. 2 after exposure to 5 tap water sprays	95.8	61.5
3. DDT-water paste (40:60) (Pebble mill)	97.5	100.0
3a. No. 3 after exposure to 5 tap water sprays	78.8	72.4
4. DDT-Pyrax-water (1:1:2) paste (Steel ball mill)	96.6	98.9
4a. No. 4 after exposure to 5 tap water sprays	75.4	57.5
5. DDT-Pyrax (1:9) (Steel ball mill)	-	98.3
5a. No. 5 after exposure to 5 tap water sprays	-	56.9

1/ The possibility of substituting kaolin for pyrophyllite was suggested by Dr. E. D. Witman, Ohio State University Research Foundation and such a mixture was subsequently processed by him for use in these tests.

The difference in susceptibility to the tap water sprays on the two days was believed to have resulted from differences in the fruit surface, all pubescence having sloughed off the fruit by July 4.

The DDT-kaolin mixture was equal to the 1943 DDT-Pyrax combination in both experiments. The DDT-water paste was inferior after the tap water sprays on June 6 but superior in the July test. This formula was made from different shipments of 1944 DDT concentrate as was the DDT-Pyrax-water (1:1:2) paste and these results were the first indication that the results obtained with formulations of 1943 material could not be duplicated with 1944 DDT in the processing equipment available. This was also indicated by subsequent field tests.

Different shipments of the 1944 DDT concentrate appeared to vary with respect to the hardness, size, or proportion of agglomerates so that when processed for specific lengths of time the end products were extremely variable. This is thought to have resulted from the use of a less highly refined material than available in 1943. The 40:60 DDT-water paste for example, when ground in a small pebble mill using 1943 DDT concentrate, was sufficiently reduced in particle size to form a thick

slurry with no excess water in 1 or 2 hours' time. Repeated processing of this material by Mr. Fahey showed that the results with respect to particle size were reproducible. This was not true of the 1944 concentrate. On several occasions after 24 hours of similar grinding the 1944 concentrate still contained agglomerates large enough to clog the sprayer filter, as well as single particles up to 75 microns in length, and with the combination still in the form of a thin slurry. It was generally in poorer physical condition for use in spray equipment than 1943 concentrate ground only 1 or 2 hours. Photomicrographs of all formulations used in field tests were made late in the 1944 season and these show that DDT-water pastes made from 1943 material contained particles very uniform in size, while all mixtures made from 1944 material contained particles covering a wide range in size. Individual particles in the 1944 concentrate ranged up to 100 microns in length and 30 in diameter. These cylindrical particles (characteristic of DDT) tended to shorten in length with continued processing before they were reduced in diameter. The presence of pyrophyllite aided in the reduction of particle size but the optimum size for use in codling moth sprays remains to be determined. Particles of DDT up to 50 microns in length were found on the surface of Rome Beauty apples when picked October 19, 50 days after the final spray. Particles of at least 30 microns in length were found adhering to the setae of newly hatched codling moth larvae.

The 1943 concentrate processed with an equal quantity of pyrophyllite remains in as fine a condition as when first prepared although it contains individual DDT particles of considerable size. The 1944 material could not be processed in a 1:1 mixture with pyrophyllite in a steel ball mill without the addition of water to prevent packing. Neither could the straight DDT-water (40:60) paste be processed in the steel ball mill but it could be made in a porcelain-lined pebble mill. All mixtures of DDT which contained water acquired a rusty color and generated some heat in the steel mill, suggesting that some decomposition may have occurred.

The use of an emulsified solution of the 1944 concentrate in tests reported below eliminated the loss which results when part of the material is in the form of excessively large particles and agglomerates, hence the solution compared favorably with the suspensions. It remains to be determined whether it can equal a properly processed dry product.

Laboratory-Field Experiments

The method used in conducting these experiments has been described in previous reports (Bureau Circular E-488, September 1939). For the tests reported herein 60-apple stratified samples were taken from each plot (generally from 2 trees) before and after the cover sprays beginning with the second, and at harvest. Ten newly hatched larvae were applied to each apple under controlled laboratory conditions. Some 325,000 larvae were used in the tests.

The trees used in 3 series of tests were of the Rome Beauty and Grimes varieties and were 25 and 24 years old respectively. Pre-bloom sprays were applied by the grower. A uniform calyx spray of 3 pounds

lead arsenate, 3 pounds lime, and 6 pounds wettable sulfur per 100 gallons was applied to all plots alike. A 7-day spray of 4 pounds lead arsenate, 4 pounds lime, and 10 pounds flotation sulfur paste was applied to all plots that were to be sprayed later with lead arsenate formulas. Those which were to receive other insecticides were sprayed only with flotation sulfur in the 7-day spray.

The trees were sprayed with approximately 33 gallons each during the cover spray period. Eight cover sprays were applied to the Grimes and 10 to the Rome Beauty. All except the last Rome Beauty spray were applied from both tower and ground to the point where run-off occurred from all parts of the tree. The final Rome Beauty spray was from the tower only but 20 gallons per tree were applied.

Cover sprays were applied on the following dates:

Spray Number	Rome Beauty	Grimes	Spray Number	Rome Beauty	Grimes
1	May 17-18	May 19	6	July 8, 10	July 14
2	May 23-25[1/]	May 27	7	July 21-22	July 28
3	June 1-2	June 6	8	Aug. 7-8	Aug. 14
4	June 12-13[1/]	June 16	9	Aug. 21-22[1/]	-
5	June 26-27	June 30	10	Aug. 29-31[1/]	-

1/ Interrupted by rains.

The Rome Beauty plots were arranged in a restricted randomization of 7 single-tree replicates. The series contained 15 treatments for which the final infestation data will be found in Table 4. Larvicidal efficiency data and deposit data were obtained from 10 of the treatments, an extra 2-tree replicate being sprayed for the purpose. No final infestation data were obtained from the unreplicated Grimes plots.

Because of the great amount of detailed data involved the individual paired efficiency and deposit determinations are omitted from this report. The averages for the season and the final deposits and efficiency immediately before harvest are given for those treatments continued throughout the entire season, or in the case of the third series from June 30 to September 6.

Rome Beauty

Efficiency and deposit data obtained from the Rome Beauty variety are given in table 1. Reference should be made to table 4 for details of the spray treatments.

Abbreviations used to indicate spray materials referred to in the tables in this report are listed below:

301 oil (a raw mineral oil of 85% U. R. and 57 sec. viscosity)

370 oil (a raw mineral oil of 80% U. R. and 57 sec. viscosity)

371 oil (a raw mineral oil of 80% U. R. and 72 sec. viscosity)

501 oil (a raw napthenic mineral oil of 90% U. R. and 54 sec. visc.)

Bdx.-1/2 (1/2:1:100 bordeaux mixture)

Bdx.-1 (1:2:100 bordeaux mixture)

CSCP (Central Soya Co. crude soybean phosphatides)

DDT (dichloro diphenyl trichloroethane) (Ground with water into a 40:60 paste)

DDT-P (a 1:1:2 mixture of DDT-pyrophyllite-water ground in a steel ball mill)

DDT-1:9 (a 1:9 mixture of DDT concentrate and pyrophyllite ground dry in a steel ball mill)

Fermate (ferric dimethyl dithiocarbamate)

FPNB (factory processed nicotine bentonite, 14%)

He 175 (disodium ethylene bis dithiocarbamate)

LA (acid lead arsenate)

KWK (Wyoming bentonite, pellet form)

Li (hydrated spray lime)

MDM 1:5 (micronized dry mix, 1 pt. nic. to 5 lb. KWK powder)

MO (an emulsive 97% mineral oil of 91% U. R. and 57.7 sec. visc.)

Nic. (nicotine sulfate, 40%)

PC (Panther Creek, Mississippi bentonite)

PCN (para chloro ortho nitro acetanilide)

S (sulfur, flotation paste)

SF (soybean flour)

SO (soybean oil, crude)

X110 (Filtrol X110, Mississippi bentonite)

YST (a commercial preparation of 55 percent soybean lecithin + oil and carbitol

ZS (zinc sulfate)

Table 1. Average percent larvicidal efficiencies and spray deposits from May 25 to Sept. 16. Rome Beauty. Vincennes, Ind. 1944

Plot	Treatment (for details see table 4)	Deposits[1]	0-2 days after sprays	9-16 days after sprays	Final 9/17
1.	Standard lead arsenate, oil, bordeaux		58	53	61
		As_2O_3	(19.3)	(11.3)	(14.7)
3.	Reduced lead arsenate, bordeaux, DDT-P		89	72	85
		As_2O_3	(12.6)	(7.6)	(10.3)
		DDT[2]	(4.4)	(3.0)	(3.9)
5.	Standard tank mix nicotine bentonite (KWK), soybean oil. 301 oil + nicotine in last 3 sprays		92	81	81
		Nicotine	(5.8)	(3.7)	(2.3)
7.	Nicotine bentonite (X110), 301 oil, Fermate in 2 sprays, CSCP in 4		92	83	95
		Nicotine	(3.9)	(1.9)	(2.2)
8.	Nicotine bentonite (X110) soybean oil		95	82	96
		Nicotine	(4.8)	(2.2)	(3.5)
9.	Nicotine bentonite (X110) 371 oil. Soybean oil in first, fifth, and final sprays		90	84	97
		Nicotine	(4.9)	(2.0)	(4.6)
11.	DDT-P, 3/4 lb. in 7 sprays, 1/2 lb. in 3. MO and KWK in 2 of the DDT sprays		96	82	94
		DDT	(7.8)	(4.4)	(11.4)
12.	DDT-P, 1 lb. in 7 sprays, 2/3 lb. in 3		98	82	86
		DDT	(8.5)	(3.8)	(6.9)
13.	DDT-P, 1-1/2 lb. in 7 sprays, 1 lb. in 3. MO and KWK in 2 of the DDT sprays		100	93	99
		DDT	(12.1)	(7.7)	(16.9)
14.	DDT, 1 lb. in 7 sprays, 2/3 lb. in 3		97	80	77
		DDT	(7.7)	(3.8)	(4.9)

1/ Deposits as mmg. per cm^2 are shown by figures in parenthesis.
2/ Between 6th cover spray and harvest.

Because of the hot dry weather and lack of dews during mid season the standard lead arsenate (1) declined in efficiency after the third cover spray to a low of 39 percent on July 6 although its deposits on that date averaged 12.4 mmgs. As_2O_3 per sq. cm. The adverse effect of prolonged periods of hot dry weather on the toxicity of lead arsenate deposits has been noted almost every year of the past 11. Plot 1 reached its highest efficiency of the season (68.2 percent) on August 18 immediately before the ninth cover spray and after 5 rainy days during which a total of 1.3 inches of rain fell. There was an increase of 43 injuries per 100 apples on this plot between June 20 and July 17, of 75 between July 17 and August 11, and of 34 between August 11 and 25. During these 3 periods the respective increases on the lead arsenate plot supplemented with DDT (3) were 12, 28, and 8. On the nicotine bentonite-soybean oil plot (8) they were 3, 11, and 6.

On Plot 3, the DDT deposits were not determined early in the season but after July 10 they averaged 3.7 mmg. per sq. cm. compared to 6.8 on Plot 12 to which was applied 2-1/2 to 4 times as much DDT. Apparently the presence of lead arsenate or bordeaux mixture was responsible for increasing the resistance of the DDT to weathering.

As in 1942 and 1943, the Mississippi bentonite programs were more effective late in the season than those of Wyoming bentonite, primarily because Wyoming bentonite and soybean oil in the original formula must be replaced by mineral oil in the late applications to avoid excessive visible residues. The results also indicate that 1/2 percent soybean oil may be as effective as 1/2 percent mineral oil in the Mississippi bentonite formula. Treatments 7, 8, and 9 were highly effective in late August and early September after the fruit began to form considerable wax. The soybean oil formula produces a more uniform deposit than the mineral oil mixture and one which is less greasy and more easily removed by brushing. Furthermore, soybean oil does not retard color formation as much as does mineral oil.

Because of the need for information on the influence of mineral oil on the European red mite population that was rapidly building up and to test the safety of 1/2 and 3/4 percent oil-DDT mixtures to the trees after some bronzing had developed and because it was impossible to expand the experimental setup further, oil was added to treatments 11 and 13 in the sixth and seventh cover sprays. It was recognized that this would probably interfere with the comparison of the 3 dilutions of DDT-Pyrax being tested. The oil had a more pronounced and prolonged effect than anticipated.

This is shown by the data in Table 2.

Table 2. A comparison of the average larvicidal efficiency and amount of DDT deposits before and after the addition of mineral oil and bentonite to certain formulas. (Deposits in mmg. per sq.cm.)

Period	Age of latest deposits		Plot 11 3/4 lb.+ Pyrax	Plot 12 1 lb. + Pyrax	Plot 13 1.5 lb. + Pyrax	Plot 14 1 lb. (Paste)
2nd to before 6th cover	Fresh	% Effic.	98.3	98.4	99.4	97.3
		Deposit	7.4	8.2	9.8	6.7
	Weathered	% Effic.	72.5	75.7	86.0	79.1
		Deposit	3.2	4.0	5.7	3.4
After 6th to before 8th cover. (Oil and bentonite added to #11 and 13)	Fresh	% Effic.	90.6	98.8	99.6	95.5
		Deposit	7.7	9.8	13.0	8.2
	Weathered	% Effic.	87.8	84.9	98.4	78.8
		Deposit	5.8	3.4	11.2	4.0
After 8th to harvest (9/17) (No oil or bentonite)	Fresh	% Effic.	98.1	97.2	99.8	97.2
		Deposit	11.4	8.6	22.7	11.6
	Weathered	% Effic.	92.4	89.2	99.1	80.5
		Deposit	9.4	6.3	15.6	5.3

Note: The DDT used on Plots 11, 12, 13, and 14 was reduced to 1/2, 2/3, 1, and 2/3 lbs. respectively in 6th, 7th, and 8th cover sprays. First-brood formulas resumed for 9th and 10th covers.

Average rainfall in inches per interspray period: 2nd to 6th cover sprays-1.14
6th to 8th cover sprays-0.87
8th to harvest - 2.05

Prior to the use of the mineral oil and 1/4 lb. Wyoming bentonite on Plots 11 and 13, their efficiency and deposits compared about as expected. While the oil was being used the fresh deposits also ranked in accordance with the strength of DDT in the formulas. The oil and bentonite, however, increased the resistance to weathering so that the 1/2 pound DDT formula with oil (11) was superior after periods of weathering to the formula containing 2/3 pound DDT without oil. Treatment 13 was correspondingly better and lost almost no efficiency between sprays. Its lowest efficiency was 75 percent on May 31. After June 28 it never fell below 97.7 percent. From June 20 to August 25 it permitted an increase of only 9 injuries (mostly stings) per 100 apples. Although no oil deposits were visible after the eighth cover, some bentonite remained and the influence of the oil or bentonite (or both) used in the sixth and seveth covers was apparent until harvest, not so much while the deposits were fresh, as after they had been exposed to weathering.

It remains to be determined whether a properly processed dry DDT-Pyrax mixture such as used in 1943 would be influenced as much by the addition of oil or whether any DDT mixture of this kind will perform better when applied over, or with, some material such as lead arsenate, bordeaux, or bentonite that will make a bond with the fruit surface more resistant to weathering than can be obtained with DDT-Pyrax or DDT alone.

Another factor which may account for greater resistance to weathering late in the season is the great increase in the amount of wax formed on the surface of the fruit. This usually rises through the spray deposit tending to submerge rather than loosen spray residues. The Rome Beauty variety is especially waxy while the Grimes up to September 1 had produced very little.

The performance of the DDT-water paste formula (14) was equal to that of the Pyrax mixture (12) early in the season, but the paste was less effective during the latter part. As already stated, the DDT-water pastes (Plot 14) prepared during the season varied considerably in their physical nature. Some were obviously too coarse since they clogged the sprayer screen under pressure. The paste also was thrown out of suspension in the tank while the last spray was being applied, which resulted in poor coverage on part of the plot. They was caused by the presence of 1/2 pint Sherwin-Williams "Stop-Drop" (naphthalene acetic acid solution) per 100 gallons which did not visibly affect the mixtures containing Pyrax or other materials.

Grimes

Efficiency and deposit data from the principal series on the Grimes variety are summarized in table 3.

Table 3. Average percent larvicidal efficiencies and spray deposits from May 26 to Sept. 1, Grimes, Vincennes, Ind. 1944

Plot	Cover sprays	Materials per 100 gals. (Actual quantities DDT are given)	Deposits[1]	0-2 days after sprays	7-18 days after sprays	At harvest
16	7-day	4 lb.LA,4 lb.Li., 10 lb. S				
	1	4 lb.LA,Bdx.-1/2,4 oz.SF		64	52	50
	2-4	4 lb.LA,Bdx.-1/2,2 qt. MO	As_2O_3	(17.2)	(13.1)	(17.0)
	5-8	3 lb.LA, Bdx.-1/2				
17	7-day	4 lb. LA, 1 lb. Fermate				
	1	4 lb. LA,0.5 lb.Fermate, 4 oz. DDT-P				
	2	4 lb.LA,0.5 lb. Fermate, 4 oz.DDT-P,2 qt. MO		91	73	58
	3-4	2 lb.LA,0.5 lb.Fermate, 4 oz. DDT-P, 2 qt. MO				
	5-8	3/4 lb. DDT-P				
18	1	1 pt.Nic.,8 lb.X110,1 pt.SO				
	2	1 pt.Nic.,8 lb.X110,1 qt.SO				
	3-4	1 pt.Nic.,8 lb.X110,2 qt. 301 oil		94	82	73
	5-7	2/3 pt.Nic.,5 lb.X110, 2 qt. 301 oil	Nicotine	(5.0)	(2.8)	(2.7)
	8	2/3 pt.Nic.,5 lb.X110, 1 qt.SO				
19	1-7	Same as 18 + 1 lb. He 175		94	81	75
	8	Same as 18	Nicotine	(4.2)	(2.2)	(2.5)
20	1-8	Same as 18 except PC substituted for X110	Nicotine	91 (4.6)	80 (2.5)	71 (1.7)
21	1-5	1 lb. DDT-P		97	81	46
	6-8	3/4 lb. DDT-P	DDT	(9.3)	(6.2)	(6.8)
22	1-2	1 lb. DDT-P				
	3-5	1 lb.DDT-1 hr.grind (Pebble mill)		96	80	50
	6-8	3/4 lb.DDT-1 hr. grind (Pebble mill)	DDT	(8.4)	(5.3)	(5.6)
22A	1-2	1 lb. DDT-P				
	3-5	1 lb.DDT-24 hr. grind (Pebble mill)		97	82	59
	6-8	3/4 lb.DDT-24 hr. (Pebble mill)	DDT	(8.3)	(5.5)	(6.5)
24	1	1 lb. DDT-P, 4 ozs. KWK, 1 pt. MO				
	2-5	1 lb. DDT-P, 4 ozs. KWK, 1 qt. MO		99	90	94
	6-8	3/4 lb. DDT-P, 4 ozs. KWK, 1 qt. MO	DDT	(14.4)	(9.7)	(13.3)
26	1-5	1 lb. DDT-P, Bdx.-1		99	89	85
	6-8	3/4 lb. DDT-P, Bdx.-1	DDT	(8.2)	(6.7)	(7.0)
27	1-5	1 lb. DDT-1:9		97	85	60
	6-8	3/4 lb. DDT-1:9	DDT	(9.6)	(6.7)	(7.0)
28	1-4	Dust, DDT-talc-301 oil (5:95:5)		81	41	32
	5-8	Dust, DDT-talc-pyrophyllite (5:7.5:87.5)	DDT	(4.5)	(2.6)	(2.9)
29	1-8	Dust, DDT-Walnut shell flour (5:95)	DDT	87 (4.5)	48 (3.2)	30 (3.8)

1/ Deposits as mmg. per cm^2 are shown by figures in parenthesis.

During the period when lead arsenate was used with Fermate and DDT on Plot 17 the efficiency of the combination averaged 82 percent immediately after spray applications and 53 percent after periods of weathering compared to 54 and 40 percent respectively for the standard lead arsenate.

The results obtained with the two Mississippi bentonites were about equal (18 and 20) and the addition of 1 pound of He-175 (disodium ethylene bis dithiocarbamate) per 100 gallons to the X110 formula (Plot 19) had no effect on efficiency, although slightly lower nicotine deposits resulted. With a few exceptions (Plots 24 and 26) the nicotine bentonite plots withstood the heavy rains late in August better than DDT.

The fungicide used on Plot 19 caused severe injury to the fruit which first appeared as glossy black spots. The majority of these later expanded with growth and produced a russet (except where more than skin deep) which in turn gradually sloughed off. However, 65 percent of the fruit was still badly spotted at harvest with up to 40 spots per apple ranging from 2 to 8 mm. in diameter. The fungicide therefore must be considered unsafe for use with nicotine bentonite and mineral or soybean oil in this area.

These tests indicate that as far as the effectiveness of deposits on the fruit are concerned all DDT formulas tested except the DDT dusts were superior to lead arsenate. The dusts were inferior only after periods of weathering. They were applied on the same schedule as the sprays but around 6:00 A.M. so as to take advantage of dews when such occurred. About 2 to 3 pounds of the 5 percent dust was used per tree per application.

There was a greater difference between the average efficiency in the tops and bottoms of dusted than sprayed trees especially after periods of weathering. This is shown by the following data from representative plots.

Percent efficiency of:		Plot 16	18	21	24	28	29
Fresh deposits	Top	57	89	94	99	67	75
	Bottom	65	96	98	100	87	93
Weathered deposits	Top	45	75	73	87	26	32
	Bottom	58	84	87	92	52	54

In comparison with nicotine bentonite and mineral oil (Plots 18 and 20) the DDT spray deposits were more effective when fresh but only 3 of the mixtures were more effective after periods of weathering.

Contrary to expectations the 1:9 DDT-Pyrax dry mix (27) proved superior to the 1:1:2 DDT-Pyrax-water paste (21). This is another of the reasons we suspect the latter of not being as effective as a properly prepared 1:1 dry mixture such as used in 1943. The results on Plot 24 where oil and bentonite were added were outstanding, particularly after the heavy rainfall late in August, likewise the results on Plot 26 where bordeaux was added. These results also suggest that the 1:1:2 paste when used alone

was not so effective as the 1943 material. The latter withstood rainy weather in early September 1943, over a longer period of weathering, better than any treatment did in 1944 except Nos. 24 and 26.

The DDT-water paste (22 and 22A) gave slightly better results when ground for 24 hours than 1 hour. The difference between these plots increased toward the end of the season. Furthermore, after June 30 the DDT-water paste (24 hour grind) remained superior to the 1:1:2 DDT-Pyrax-water paste. In June it had lost efficiency much more rapidly during the interspray periods.

In this series of tests the efficiency of DDT mixtures declined much more rapidly after the last spray than occurred on Rome Beauty. Varietal differences, particularly with regard to the amount of wax being formed during the period, may have been responsible. A dashing rain of 1.04 inches lasting about 30 minutes began about 1 hour after the completion of the final cover spray on the Grimes. Six DDT spray plots which before this spray averaged 8.5 mmg. DDT per sq. cm. averaged only 8.2 after the rain, yet retained 7.7 mmg. at harvest after additional rains of 4.63 inches. The final loss was less than was accounted for by growth alone. Despite the removal by the first rain of more DDT than was put on in the last application, the average efficiency increased slightly from 87 to 89 percent but declined thereafter to 65.6 percent. It is concluded from this and the visible accumulation of DDT around stems that there was considerable removal of DDT residues from foliage and fruit surfaces and redeposition in the stem basins during the rainy periods.

The DDT-kaolin dry mixture (see page 39) was applied to part of Plot 21 in the last 2 sprays. Its performance before the final spray did not significantly differ from that of Plot 21. However, although it was the last plot sprayed before the 1.04-inch rain and was barely dry it showed an increase of 4.5 mmgs. per sq. cm. in deposit and 14.1 percent in efficiency. Its efficiency dropped from 99 and 67 percent during the final period compared to a decline from 87 to 46 on Plot 21.

A separate series of tests was started on Plot 20 (nicotine bentonite) beginning with the fifth cover spray. These sub-plots all received DDT in 5 sprays, the final being applied on August 28. The final sample was taken September 6. The residual efficiency on June 29 of the first-brood nicotine bentonite sprays was 87 percent. The average efficiencies of fresh and weathered DDT deposits follow:

Quantities per 100 gallons	0-1 day after sprays	9-17 days after sprays	Aug. 28 after 5.07" rainfall
1. DDT-water (40:60) paste (1.2 lb. DDT)	92	74	47
2. No. 1 + 2 lb. PC	94	77	51
3. No. 1 + 1 qt. SO and 1 lb. KWK	90	69	59
4. No. 1 + 0.5 oz. Dreft	91	68	37
5. DDT concentrate (1/2 lb.) dissolved in 1 pt. benzene, emulsified with 1/2 oz. Rohm and Haas 1956	95	69	54

PC (para chloro ortho nitro acetanalid) was added to DDT (2) for the control of European red mite and may have been partly toxic to codling moth. Crude phosphatides in the soybean oil caused the soybean oil-DDT mixture (3) to break in the tank during the application of the first two sprays when the bentonite was used at 1/4 pound and 1/2 pound respectively.

Among the Grimes plots which were discontinued was one receiving 1/2 pound DDT-P, 1/2 pound KWK, 1/2 pound Fermate, 6 ounces CSCP, and 1 pint to 1 quart 301 oil per 100 gallons. The first application severely burned foliage inside the tree and on lower breanches and stopped growth of the fruit. The second application added to the injury and nearly half the crop dropped. The reason for the injury is not clear, since each ingredient has been used with DDT in other formulas without injury. It is suspected, however, that there was a reaction between DDT and Fermate.

PN (para nitro acetanalid) first at 2, then 3 pounds per 100 gallons supplemented with kaolin or Bancroft clay proved ineffective against codling moth and was discontinued after 6 cover sprays. The average larvicidal efficiency of its fresh deposits was 56 percent and of its weathered deposits only 28 percent.

Comparative Efficiency of Foliage Deposits

In tests on Rome Beauty and Turley both nicotine and DDT residues on foliage prevented most larvae from reaching or entering unsprayed apples tied near the base of leaves on which newly hatched larvae were placed. Fresh deposits were extremely effective.

Two experiments were conducted in June and July, one on fresh deposits, the other after 10 days of weathering. For each test 50 apples and 500 newly hatched larvae were used, 2 larvae being placed on each of the 5 leaves nearest the apple. Only 1 apple was used per twig. The results follow:

Treatment	Worm entrances in unsprayed apples	
	Fresh deposits on foliage	Weathered deposits on foliage
	Percent	Percent
Unsprayed foliage (check)	24.8	27.8
Standard lead arsenate	-	25.4
X110 bent., Nic., oil	2.6	9.2
DDT-P (1 lb. DDT per 100 gal.)	0.2	8.0

Field Tests of Insecticides on Randomized Plots

Rome Beauty (7 single-tree replicates per plot)

Infestation data representing all drops and picked fruit on 16 treatments including the 10 listed in table 1 are summarized in table 4. The plots were arranged in an 11 x 17 row block with the trees set 40 x 40. Two of the 11 rows crossing the middle of the block were of the Turley variety and were divided into a separate series of plots.

Twenty bait traps distributed in trees sprayed by the grower along two sides of the area captured 18,800 moths during the season compared to 9,000 in 1943. In 1943 the fruit on experimental plots in this area ranged from 66 to 91 percent clean. The average plot yields ranged from 3,400 to 4,600 apples per tree. In 1944 the plot yields ranged from 1,500 to 2,500 apples per tree and the fruit from 12 to 90 percent clean.

Table 4. Results of Small Plot Field Tests on Rome Beauty. Vincennes, Ind. 1944 (Plots numbered same as in Table 1)

Plot	Cover Sprays	Materials per 100 gals.[1] (DDT given as amount of concentrate)	Average per tree June 22 Worms (No.)	Average per tree June 22 Stings (No.)	Seasonal Data Clean apples (%)	Seasonal Data Wormy apples (%)	Worms and stings per 100 apples (No.)
1.	7-day 1 2-4 5-10	4 lb.LA,4 lb.Li., 10 lb.S 4 lb.LA,Bdx.-1/2,4 oz.SF 4 lb.LA,Bdx.-1/2,2 qt.MO 3 lb.LA,Bdx.-1/2	36	163	11.5	75.6	301
2.	Same as Pl. 1 except 2 oz. YST added and 301 oil substituted for MO		45	114	16.4	69.2	269
3.	7-day 1-2 3-4 5-10	4 lb.LA,4 lb.Li., 10 lb.S Same as Pl.1 + 4 oz.DDT-P 2 lb.LA,Bdx.-1/2,2 qt. MO, 4 oz.DDT 2 lb.LA,Bdx.-1/2,4 oz.DDT	5	82	49.7	33.7	82
4.	1 2 3-5 6-8 9-10	1 pt.nic.,8 lb.PC,1 pt. 301 oil,8 oz.CSCP,1/2 lb. Fermate 1 pt.nic.,8 lb.PC,2 qt.301 oil,8 oz.CSCP, ½ lb. Fermate 1 pt.nic.,8 lb.PC,2 qt. 301 oil,8 oz.CSCP 2/3 pt.nic.,5 lb.PC,2 qt. 301 oil 1 pt.nic.,8 lb.PC,2 qt. 301 oil	74	129	37.2	55.3	95
7.	Same as Pl. 4 except X110 substituted for PC		47	118	42.6	49.9	84
5.	1-5 6-7 8-10	1 pt.nic.,5 lb.KWK,1 qt.SO 2/3 pt.nic.,3-1/3 lb. KWK, 1 qt. SO 2/3 pt. nic.,1/2 lb. KWK, 3 qt. 301 oil	88	155	44.8	44.4	84
6.	1 2-5, 9-10 6-8	1 pt.nic.,8 lb.X110,1 pt.MO 1 pt.nic.,8 lb.X110, 2 qt. MO 2/3 pt.nic.,5 lb.X110, 2 qt. MO	46	139	60.3	32.8	52
8.	1 2-10	1 pt.nic.,8 lb.X110,1 pt.SO Same as Pl. 6 except 1 qt. SO substituted for the MO	121	199	51.2	39.3	64
9.	1 2-4 5,9-10 6-8	1 pt.nic.,8 lb.X110,1 pt.SO 1 pt.nic.,8 lb.X110,2 qt. 371 oil 1 pt.nic.,8 lb.X110,1 qt.SO 2/3 pt.nic.,5 lb.X110, 2 qt. 371 oil	84	152	66.5	26.8	42

Table 4 (continued)

Plot	Cover sprays	Materials per 100 gals.[1] (DDT given as amount of concentrate)	Average per tree June 22: Worms (No.)	Average per tree June 22: Stings (No.)	Seasonal Data: Clean apples (%)	Seasonal Data: Wormy apples (%)	Worms and stings per 100 apples (No.)
10.	1-2	Same as Pl. 7					
	3-10	1/2 pt.nic.,4 lb.X110, 2 qt. 301 oil,8 oz.CSCP, 3 oz.ZS	72	93	36.7	55.2	95
15.	1	6 lb.MDM,1 pt.301 oil, 6 oz.CSCP					
	2	6 lb.MDM,2 qt.301 oil, 6 oz.CSCP	38	69	57.6	36.1	58
	3-10	3 lb.MDM,2 qt.301 oil, 4 oz.CSCP					
11.	1-5, 9-10	3/4 lb. DDT-P					
	6	1/2 lb.DDT-P,4 oz.KWK, 2 qt.MO	12	60	62.8	13.8	55
	7	1/2 lb.DDT-P,4 oz.KWK 3 qt.MO					
	8	1/2 lb.DDT-P					
12.	1-5, 9-10	1 lb. DDT-P	6	53	67.2	18.0	45
	6-8	2/3 lb.DDT-P					
13.	1-5, 9-10	1-1/2 lb. DDT-P					
	6	1 lb.DDT-P,4 oz.KWK,2 qt.MO	7	55	90.1	1.8	12
	7	1 lb.DDT-P,4 oz.KWK,3 qt.MO					
	8	1 lb.DDT-P					
14.	1-5, 9-10	1 lb.DDT (1 hr. grind)	17	63	45.7	33.2	85
	6-8	2/3 lb. DDT (1 hr. grind)					
31.	Same as Pl. 12 on small replants. (206 apples per tree)		--	--	42.0	26.7	90
32	1-2	2 lb. PN					
	3-10	3 lb. PN	--	--	13.7	82.1	176
	(Comparable to Pl. 31 only, 734 apples per tree)						

1/ All nicotine and DDT plots received 10 lb. S in a 7-day spray. One half pint naphthylene acetic acid solution per 100 gals. was included in 10th spray on all plots.

Outstanding control of first-brood worms was effected by all the formulas containing DDT (3, 11, 12, 13, 14). Ranking next were the lead arsenate and nicotine treatments (except Plot 9) which received 1/2 percent mineral oil in the second, third, and fourth cover sprays. Plots 5, 8, and 9 gave the poorest results in the first-brood period, the first 2 because of their comparatively low ovicidal efficiency and 9 because of a lower larvicidal efficiency. The heavier oil used on Plot 9 produced a very spotted coverage until several sprays were applied.

Because of the early and concentrated attack beginning at the time of the second cover spray, formulas having a high ovicidal value were more efficient in 1944 than usual.

The use of DDT as a fortifying agent for lead arsenate was suggested by the performance of DDT when applied over lead arsenate residues in 1943 and by the results of subsequent laboratory tests. Substitution of 4 ounces DDT for 1 to 2 pounds of lead arsenate in the standard lead arsenate formula reduced wormy fruit more than one-half and gave as good results as a straight DDT-paste (14) at 1 pound DDT per 100 gallons.

Although control was unsatisfactory all the nicotine bentonite treatments were much superior to standard lead arsenate. The infestation on Plots 1 and 2 was close to the saturation point with 70 percent of the crop falling to the ground.

The results with Plots 4 and 7 again, as in previous years, suggest that the X110 brand of Mississippi bentonite is slightly more effective than the Panther Creek. In 1943 the raw 301 oil was much superior to the ready mix type. The reverse was true in 1944 (Plot 6 vs. 7) but the use of Fermate and soybean phosphatides with the raw oil may have reduced the effectiveness of the formula. Substitution of soybean oil on Plot 8 and in 3 covers on Plot 9 reduced the adverse effect of too much mineral oil on the fruit and foliage although the fruit from Plot 9, the most effective nicotine bentonite treatment, was still too oily at harvest.

As shown by the larvicidal efficiency tests, the use of oil with DDT in two sprays substantially improved the effectiveness so that at harvest the 3/4 pound formula (11) equalled the 1 pound formula (12) which received no oil. Plot 13 with 1.5 pound DDT in 7 sprays and 1 pound in 3 with oil in 2 gave remarkable control considering the intensity of the infestation in the area. It had only 1.8 percent wormy fruit.

Although the DDT plots showed a considerable increase in stings late in the season, these sting injuries were very small and inconspicuous.

The fruit on these plots ranged in size from 128 per box on Plot 6 to 173 on Plot 13. On other DDT plots where mite damage was more severe than on 13 it ranged from 142 to 155 and on other nicotine plots the range was from 134 to 151. There is some evidence therefore that the heaviest DDT dosage reduced the size of fruit. Either the DDT or the mite infestation was responsible for a delay in maturity of Rome Beauty wherever DDT was used on this variety.

Turley (5 single tree replicates)

These were mature trees requiring 35 gallons spray material each per application. The results are given in table 5.

Table 5. Results of Small Plot Field Tests on Turley. Vincennes, Ind. 1944

Plot	Cover spray[1]	Materials per 100 gals.[2] (DDT given as amount of concentrate)	Average per tree June 20 Worms (No.)	Average per tree June 20 Stings (No.)	Seasonal Data Clean apples (%)	Seasonal Data Wormy apples (%)	Worms and stings per 100 apples (No.)
1.	7-day	4 lb.LA,4 lb.Li.,10 lb. S					
	1	4 lb.LA,Bdx.-1/2,4 oz. SF	112	257	24.1	56.1	208
	2-4	4 lb.LA,Bdx.-1/2,2 qt. MO					
	5-10	3 lb.LA, Bdx.-1/2					
2.	1-5,) (9-10	1 lb. DDT-P					
	6-7	2/3 lb.DDT-P,Bdx.-1/2, 2 qt. 301 oil	14	67	71.6	10.8	40
	8	2/3 lb. DDT-P					
3.	1	1 pt.nic.,8 lb.X110, 1 pt. 301 oil					
	2-5,) (9-10	1 pt.nic.,8 lb. X110, 2 qt. 301 oil	48	96	67.4	22.5	40
	6-8	2/3 pt.nic.,5 lb.X110, 2 qt. 301 oil					
4.	1-2	Same as Pl. 3					
	3-10	1/2 pt.nic.,4 lb.X110, 2 qt. 301 oil, 4 oz. DDT-P	68	115	82.9	8.9	20
5.	1	3 lb.FPNB,1 pt. 301 oil					
	2-5,) (9-10	3 lb. FPNB, 2 qt. 301 oil	43	106	63.9	24.3	55
	6-8	2 lb. FPNB, 2 qt. 301 oil					
6.	1-5	1 pt. nic.,5 lb. KWK, 1 qt.SO					
	6-10	Same as Pl. 5	44	182	62.0	25.8	54

1/ Cover sprays applied 5/16, 22-23, 31, 6/10, 24, 7/7, 20, 8/5, 19 and 29.
2/ Nicotine and DDT plots received 10 lb. S in a 7-day spray.

The outstanding treatment in this series was the mixture of DDT (4 oz.) and half strength nicotine bentonite oil (Plot 4) although it is evident that the DDT should have been started with the first cover spray. Before this plot was split off from Plot 3 it had acquired a heavier infestation. The difference between the two at the end of first-brood attack cannot be considered significant.

This combination formula or the lead arsenate-DDT formula (Plot 3, table 4) are believed to be the safest available at present for grower use. The DDT dosages are apparently low enough to avoid destructive increases in the mite population, which is also partially checked by the oil used in the formulas.

In this series of tests the straight DDT plot (2) proved twice as effective as the standard lead arsenate.

Despite the dry season which was of considerable benefit to the factory processed nicotine bentonite (5) this material remained slightly inferior in control of worm and sting injuries to the tank mix Mississippi bentonite nicotine formula (3). The split schedule (6) was cheaper but no more effective than the full season factory processed nicotine bentonite schedule.

Ben Davis (6 single-tree replicates)

Formulas 1, 2, and 3 in the Turley experiments were repeated on a nearby block of Ben Davis and 6 variations of the tank mix Mississippi bentonite nicotine formula added. The block was three rows wide and bordered by Duchess along one side from which a heavy flight of moths came after Duchess harvest in July.

Treatments and results are given in table 6.

Table 6. Results of Small Plot Field Tests on Ben Davis, Vincennes, Ind. 1944

Plot	Cover spray	Materials per 100 gals. (DDT given as amount of concentrate)	Average per tree June 23 Worms (No.)	Average per tree June 23 Stings (No.)	Seasonal Data Clean Apples (%)	Seasonal Data Wormy Apples (%)	Worms and stings per 100 apples (No.)
1.	1	4 lb.LA,Bdx.-1/2,4 oz.SF					
	2-4	4 lb.LA,Bdx.-1/2,2 qt.MO	50	198	10.2	73.4	359
	5-10	3 lb.LA, Bdx.-1/2					
2.	1-5, 9-10	1 lb. DDT-P					
	6-7	2/3 lb.DDT-P,Bdx.-1/2, 2 qt. 301 oil	6	70	70.4	8.9	41
	8	2/3 lb. DDT-P					
3.	1	1 pt.nic.,8 lb.X110,1 pt. 301 oil					
	2-5, 9-10	1 pt.nic.,8 lb. X110,2 qt. 301 oil	52	135	37.2	51.2	105
	6-8	2/3 pt.nic.,5 lb.X110, 2 qt. 301 oil					
4.	1-10	Same as Pl. 3 except 370 oil substituted for 301	41	117	41.0	46.5	92
5.	1-10	Same as Pl. 3 except 371 oil substituted for 301	45	114	56.6	34.9	56
6.	1-10	Same as Pl. 3 except 501 oil substituted for 301	89	189	35.2	53.4	108
7.	1-10	Same as Pl. 3 except 1 qt. SO substituted for 301	79	271	56.4	29.8	63
8.	1-10	Same as Pl. 7 except PC substituted for X110	64	213	55.5	32.2	60
9.	1-10	Same as Pl. 3 except 2 oz. YST substituted for 301	156	287	46.2	40.6	77

In the control of first-brood worms lead arsenate was equal to the nicotine bentonite formulas. Plot 9 (nicotine bentonite with a small amount of spreader substituted for oil) was least effective against first-brood worms but it gave better results thereafter than the 301 and 501 oils. Oils 301, 370, 371, and 501 sell in 55 gallon drums from 17 to 38 cents per gallon compared to around 60 cents for the emulsive type. The excellent emulsifying property of nicotine bentonite and evidence that cheaper raw oils of lower unsulfonatable residue content could be used with greater safety than possible in lead arsenate formulas made it advisable to test several of this type. Except for the 72 viscosity oil they were inferior at 1/2 percent to soybean oil at 1/4 percent. However, some evidence has been obtained which indicates that no one oil among those tested will give the best results on all varieties. For example, on a waxy variety like Rome Beauty soybean oil or emulsive type mineral oils may be best for use with nicotine bentonite, while on an easily wet variety like Turley the raw oils with less spreading action have given the best results.

Both brands of Mississippis bentonite used in these tests have been found to contain a small percentage of sand-like abrasive material. Growers using conventional portable sprayers have reported no unusual wear but in stationary plants where as much as 4 tons of bentonite have been used per application there has been considerable wear on valves, seats and pressure regulator stems requiring their replacement one or more times per application. The wear is greatest where there is excessive overflow or very high pressures are used. Considerable wear on nozzles of a Speed Sprayer has also been reported by one owner.

Spray Injury

Considerable foliage injury developed on the Rome Beauty, Grimes, and Ben Davis lead arsenate plots. Because of this and the heavy worm attack these plots dropped 70 percent of their crop.

On nearly all plots on which oil was used some foliage injury developed after the second cover spray in lower parts of trees where sulfur residues remained. The foliage on Ben Davis trees sprayed with the soybean oil formulas also developed some injury but it is not certain that the oil was directly responsible. The four raw oils produced no injury although No. 371 has in previous years. No foliage injury could be attributed directly to DDT although serious bronzing developed as a result of mite infestations on most DDT plots.

Large Scale Test of DDT

With the cooperation of the W. C. Reed & Son Orchard Co. we were able to set up a large scale test of DDT.

The areas used were in one of the most heavily infested sections of the orchard. In 1943 under a 10 cover spray lead arsenate-oil-bordeaux program Winesaps at one end of the block averaged nearly 1 worm per apple.

All sprays were applied by the grower's regular orchard crew from a central stationary spray plant. The 8-acre (12 x 18 row) DDT area was surrounded on 3 sides by similar varieties sprayed with a tank-mix Mississippi bentonite nicotine-oil program, the same as applied to the remainder of the 265-acre orchard. In the small plot tests approximately the same nicotine program was 2 to 3 times as effective as the standard lead arsenate. The worm population in this orchard has acquired a greater than average ability to enter fruit sprayed with lead arsenate.

A uniform calyx application of 3.2 pounds lead arsenate, 4.8 pounds bentonite-sulfur, 15 pounds lime, and 0.3 gallon liquid lime sulfur was applied to the entire orchard April 29 to May 4 followed by another of the same formula except for omission of the liquid lime sulfur on May 5-10.

Ten cover sprays of the DDT-P mixture were applied to the DDT area between May 17 and August 29, the first 5 at 1 pound of DDT per 100 gallons, the last 5 at 3/4 pound. A weak bordeaux and 3/4 percent 301 oil was added to the sixth cover and the bordeaux alone to the seventh in half of the block (Jonathan, Golden Delicious, part of Rome Beauty, and Starking).

The nicotine area was given 11 cover sprays and 2 top-offs (5 gallons per tree) between May 17 and August 28. In 6 of the covers the nicotine was used at 1 pint per 100 gallons and in 6 at 0.7 to 0.8 pint. Soybean oil was substituted for 301 oil in the first, fifth, and last, and Fermate was included in the first.

The 4 men comprising the spray crew in the DDT area and these with 4 more in the nicotine area differed considerably in the thoroughness of their spraying and the amount of material applied. For example, in the DDT area the Jonathan sprayed by one of the men averaged 24 percent wormy while those sprayed by another averaged only 8 percent. The original infestation was uniform. The amount of spray material used in both areas averaged about 20 percent less than we consider necessary for thorough coverage. This, along with a light crop on Starking and Golden Delicious, the tendency of most of the varieties this year to set fruit in clusters, and a heavy carryover of hibernating worms in pruning stubs, cavities, and ground debris (the trees had been scraped) resulted in a very heavy infestation.

The results of infestation data representing all drops and picks from 70 trees (6 of each variety in the DDT area and 4 of each on opposite sides in the nicotine area) are summarized in table 7.

Table 7.- Results of Large Scale Comparison of DDT and Nicotine Bentonite. Vincennes, Ind. 1944

				Injuries per tree 6/20		Seasonal Data			
								Average per 100 apples	
Treatment	Variety	Apples per tree (No.)	Apples per bu. (No.)	Worms (No.)	Stings (No.)	Clean apples (%)	Wormy apples (%)	Worms (No.)	Stings (No.)
DDT	Starking	1,356	116	47	104	64.4	24.3	36	22
	Jonathan	3,333	224	66	101	72.2	16.0	20	16
	G. Del.	1,473	146	-	-	61.1	15.7	19	38
	Grimes	7,787	244	209	459	61.1	18.8	25	38
	Rome	4,273	199	112	131	75.7	12.2	15	18
	Average	3,644	186			66.9	17.4	23	27
N.B.	Starking	1,170	119	127	150	27.5	66.9	114	27
	Jonathan	2,866	225	158	160	39.6	48.2	65	29
	G. Del.	1,414	137	-	-	61.0	31.3	41	14
	Grimes	6,894	216	258	418	61.4	31.0	36	13
	Rome	4,192	200	369	472	36.6	57.8	86	17
	Average	3,307	179			45.2	47.0	68	20

There was no significant difference in the effect of the treatments on fruit size although the maturity of Rome Beauty in the DDT area was delayed. The least difference in percent wormy fruit occurred on Grimes probably because, as shown in laboratory-field tests, DDT did not resist weathering so well as on Grimes, while nicotine bentonite holds up as well on Grimes as any variety. The greatest difference occurred on Rome Beauty, on which DDT held up extremely well late in the season, although harvest was not completed until 50 days after the final spray and worms were still hatching more than 40 days after.

Although from 1/3 to 1/2 as much fruit in the DDT area was wormy as compared to the nicotine area more of it was stung.

The first-brood infestation was unusually heavy but most of it was located in the tops of high trees or inside clusters. No first-brood worms were found on well-sprayed surfaces.

Fifty-two traps were distributed uniformly throughout the DDT and adjacent nicotine areas. The catch approximated 36,500 moths, divided as follows:

	Moths captured per trap				
	5/2-6/24	6/25-8/5	8/6-9/2	9/3-30	Season
Period	1	2	3	4	
DDT	226	110	155	69	560
N.B.	228	227	229	81	766

The spring brood populations as indicated by the catches were of equal size in the two areas. Better control of first-brood worms resulted in a substantial reduction in first- and second-brood adults in the DDT area. However, traps nearest the nicotine areas, although they caught the same number of spring-brood moths as those in the center of the DDT block, caught 35 percent fewer first-brood moths during the second period and 22 percent fewer second-brood moths during the third period. Traps in the 3 rows on either side of the DDT area averaged 260 spring-brood moths compared to 219 in those farther away but they caught 12 percent less during the second period. This is a strong indication that there was considerable moth migration into at least half of the DDT area after a difference in the infestation had been obtained.

The application of the nicotine bentonite sprays reduced moth catches immediately, while the effect from DDT sprays was not detectable until 2 or 3 days later. The effect of the two insecticides on moth abundance over a longer period of time (as indicated by trap catches) was approximately equal. There was no noticeable difference between the two treatments in catches of diptera and crysopids. Both were as abundant as usual in all traps.

Effect of DDT on Other Insects

The total absence or very low populations of aphids on trees sprayed with DDT in 1943 was reported in the Journal of Economic Entomology, Vol. 36, pp. 560-561, August 1944. Observations in 1944 indicate that DDT as used this season has in no case entirely prevented the deposition of aphid eggs. It appears to have reduced it on Plot 13 (Table 4) but early defoliation caused by mite damage has reduced it even more by removing the immature egg laying form from the trees. Early defoliation occurred on Grimes in 1943 but not on Winesap where the spring aphid population was also nearly eliminated by DDT.

As in 1943, mite infestations increased wherever DDT was used. Although the European red mite became noticeably abundant on some trees in the 8-acre DDT area in early July and the common red spider appeared later that month the lady bird beetle Stethorus punctum moved in and partially checked the mites. Some bronzing occurred on Golden Delicious, scattered Starking and most Rome Beauty trees, but very little appeared on Grimes or Jonathan. The same delayed maturity of Romes was noted here as in the small plot tests. Apparently the relatively low DDT deposits which resulted from the use of an insufficient number of gallons spray material per tree permitted enough survival of mite predators to avoid a serious outbreak. The population of mites was sufficiently heavy, however, to maintain a constant potential menace. It averaged 19 mites and 102 eggs per leaf on Golden Delicious in one part of the block on July 20. Three-fourths percent summer oil added to the DDT spray applied to that part of the area left a population of 18 mites and 77 eggs on July 25. Mites were very scarce in the nicotine area.

In the laboratory-field setup on Grimes the DDT dusts were more toxic to beneficial insects than the sprays. Both, however, knocked down ladybird beetles, crysopids, the anthocorid mite predator Triphleps

insidious Say, syrphid flies and many others. The more effective DDT treatments also appeared toxic to Stethorus punctum which, however, was quite abundant on plots where DDT deposits were relatively low.

On July 4 one of the dusted plots averaged 238 mites and eggs per leaf, the DDT-paste plot 258 (where DDT had been used in 1943) the standard DDT-pyrophyllite 65, the same with oil only 10 and nicotine bentonite 35. Unsprayed trees averaged about 50. The standard plot increased from 65 on July 4 to 357 by the end of the month and the same with oil increased to 90. The mite population began decreasing on the dust plots in July and on others early in August. No bronzing of foliage occurred on the oil plot, the only DDT plot in this orchard that was not severely injured by mites. At first this was attributed to the repeated use of 1/4 percent summer oil. The evidence indicates, however, that DDT is actually toxic enough to mites to give good control of them if sufficiently heavy deposits can be maintained. This must, of course, be checked more accurately.

In the Rome Beauty experiments evidence was also obtained that if used strong enough, DDT may partially control mites. The mite damage as evidenced by the degree of bronzing was less on plot 13 (table 4) than on 11, 12, or 14. On July 7, plot 11 (3/4 lb. DDT) averaged 66 mites and eggs per leaf, plot 12 (1 lb.) 92, and plot 13 (1 1/2 lb.) only 24.

All DDT treatments resulted in almost complete elimination of apple leafhoppers which were abundant on trees sprayed with lead arsenate. The same was true of the woolly aphid.

On the Turley variety, where crawlers of San Jose scale infested 40 percent of the apples sprayed with lead arsenate, those sprayed with DDT were 13 percent infested and those sprayed with the nicotine bentonite-oil formulas only about 1 percent. However, the DDT plot had been sprayed in 1943 with nicotine bentonite, hence we cannot safely attribute any control of San Jose crawlers to DDT.

The foliage injury and early defoliation which developed in 1943 on Grimes sprayed with DDT again occurred in the same area and to a lesser extent on Rome Beauty in the Reed orchard. It has been possible, however, to prove rather conclusively that this resulted from mite damage, with the drouth a possible contributing factor. It occurred earliest on the lower parts of the dusted trees which had lower DDT deposits than sprayed trees but were the first to become severely bronzed. It also occurred on mite-infested unsprayed trees near DDT plots. It did not occur on Plot 24 (table 3) which had the heaviest DDT loads but where the adult mite population was held to a very low level. Early defoliation was negligible on the para chloro ortho nitroacetanalid-DDT plot where mites were partially checked. It occurred later on plot 13 than on 14 in the Rome Beauty setup though well after harvest in both cases.

Removal of DDT Residues

Experiments with a commercial fruit brush and with both laboratory and commercial type washing equipment using wash solutions of HCl, trisodium phosphate, soap, mineral oil, soybean oil, kerosene, sodium silicate and

wetting agents such as "Dreft" or "Vel", resulted in low percentages of removal of DDT residues from fruit sprayed with this insecticide. Brushing was still less effective. With one exception none of the washing solutions tested gave better than 50 percent removal.

The use of mineral oil as a supplement for DDT in the spray program increased the amount of residue and decreased the percentage removed by the cleaning methods tested.

In a laboratory washing test a heated (110° F.) oil emulsion gave poorer results than the same mixture when used at 80°.

The magnitude of DDT residues resulting from DDT formulas that were extremely effective against the codling moth did not exceed 0.10 gr. per pound of fruit.

In residue distribution studies, from 16 to 25 percent of the DDT present on fruit early in September was found around the stem on 4 percent of the total surface area.

Experiments with Moth Poisons Applied at Dusk

In a continuation of a field test begun in 1943, the same four 3.6 acre or 8 x 20 tree blocks (orchard 8 rows wide) were again employed, but the two used as checks in 1943 were given the dusk spray treatments in 1944 and the others, treated in 1943, were used as checks.

The entire orchard was uniformly sprayed in the conventional manner by the grower who used lead arsenate until mid June, then changed to factory processed nicotine bentonite and finally (in the last 2 applications) to tank-mix Mississippi bentonite-nicotine-oil.

The experimental sprays of 1-1200 nicotine sulfate (40%)-water solution were applied within a 10 to 15 minute period immediately after sunset and before moth activity reached its peak. The trees were sprayed on 17 evenings between May 11 and June 16, and 24 between June 26 and September 2. An average of approximately 1/2 gallon per tree was used in each application. Sprays were applied by one man, with the aid of a detachable boom mounted on top of a truck-mounted sprayer. From the top of the boom a cluster of 4 guns was fixed so that two would throw a coarse spray into the tops of trees on both sides of the outfit and two were directed downward toward the center of the trees. A quick-cut off was within reach of the driver.

Seven trees, distributed across the middle of each block, were used to provide infestation data. Bait traps were maintained in 5 others. The results are summarized below:

	Codling moth injuries per 100 apples and treatment				
Blocks	Final 1943 infestation		6/19/44		Final 9/9/44
A, C	Check	314	Treated	34	103
B, D	Treated	182	Check	47	155

The ratio of worms to stings was approximately 1:1. On September 9, 34.5 percent of the fruit on the trees in the sprayed area was wormy compared to 47.8 percent in the check. In 1943 the dusk sprays resulted in an apparent reduction of 42 percent in worms and stings. In 1944, after overcoming the difference set up in 1943 (the leveling effect of moth movement aided in this), the treatment effected a reduction of 34 percent in injuries. If the present infestation is compared with the final 1943 infestation the treated area produced fruit with 67 percent fewer injuries than were present there in 1943 while the reduction in the 1944 check area was 15 percent.

The overall cost of the operation approximated 20 cents per tree for the season, the average yield was 8 bushels, the difference in wormy fruit 13.3 percent of the crop (clean fruit-14 percent) or approximately 1 bushel per tree. The difference in value of wormy and worm-free Golden Delicious apples was not less than $2.00 per bushel, making a net gain of $1.80 per tree for trees planted 44 to the acre.

Most of the difference in infestation was effected during May and June while lead arsenate was being used by the grower. However, when areas as small as 3 or 4 acres are used the resistance to expanding differences in population density will eventually become great enough, on account of interplot moth movement, to slow down or stop further gains.

The average number of moths caught per trap by 5 traps in each area follows:

		May	June	July	August	September	Season
Treated	No.	159	43	50	173	82	507
	% ♀♀	34	44	33	60	-	-
Check	No.	217	59	93	231	98	698
	% ♀♀	37	50	61	63	-	-

During the season the treated areas caught 35 percent less female moths and 22.5 percent less males than the checks. It has been shown by previous work that the females feed more extensively on the nicotine solution than the males.

Investigations of Bait Traps

Although 112 traps (double glass quart jar type) were operated during the year they were used mainly to provide the information reported in connection with insecticide tests. Two ages of bait were constantly maintained in all traps.

A comparative test was made of the standard bait and one modified early in the season to fit changing temperature conditions. The comparative catches (10 traps of each) during the season follow:

Period	Average number moths per trap 5/1-6/3	6/4-6/24	6/25-8/19	8/20-9/30	Season
Bait A	467	11	274	167	918
Bait B	369	9	351	242	970
Average mean daily temperatures °F.	70.7	77.1	80.9	69.9	

Bait A - 10% dark brown sugar + 1/2 cc. oil sassafras per qt. After June 3, 1/2 gm. sodium arsenite per qt. was included.

Bait B - 10% dark brown sugar + 1/2 cc. oil mace per qt. until June 3. Thereafter 1/2 cc. bromo styrol, 1/2 gm. sodium arsenite, and 1 cc. nicotine sulfate was substituted for the oil of mace.

This was an attempt to use bait formulas best fitted for the expected temperatures. Bromo styrol baits in nearly 10 years of testing have never equalled oil of sassafras or oil of mace until continued hot weather prevailed. However, they have almost always been superior to oil of sassafras baits after July 1.

Distribution and Survival of Hibernating Larvae

Detailed examinations to determine the location of surviving larvae were made on 10 Winesap trees in the spring of 1944. The trees had been paired and half were scraped in the usual manner by the regular orchard crew, during the winter months. The scrapings were caught and burned. Pupa skins from larvae that escaped the scraping were counted on these 5 trees and the number found was compared with the number of larvae present on the unscraped trees in order to arrive at an estimate of the percentage of larvae actually destroyed by such operations. Detailed examinations of a total of 83 trees in previous years have indicated that at least 75 percent of the average population was in accessible locations on the tree or in coarse ground debris. The results of the current observations are given below:

Distribution and average number of overwintering codling moth per tree

	On trunk and main limbs, principally under rough bark: Ground line	0 to 5 ft. up	5 to 10 ft. up	Above 10 ft.	Pruning stubs	Crevices	Splits	Knots and Cavities	Total
Unscraped trees examined late in April	0	42.4	7.4	3.4	9.4	6.8	6.0	34.2	109.6
Trees scraped during winter, examined in May and June	0.6	4.0	4.4	1.4	2.6	3.6	7.8	23.0	47.4

The grower reduced his overwintering population approximately 57 percent. His men missed approximately 20 percent of the larvae under bark and 80 percent of those in cavities, splits, and pruning stubs. Probably because the trees had been scraped in the winter of 1942-43 many of the larvae were in places difficult to reach by the cleanup crew.

The ground population averaged less than 1 worm per tree, which was the lowest ever recorded here for mature trees on uncultivated soil. However, rainfall during the pupation period was excessive and may have driven larvae from cocoons in ground debris as noted in previous years. These may have found the tree after the scraping was done.